Addison-Wesley

Biology

Teacher's Resource Book

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Foreword

The materials in the *Addison-Wesley Biology* Teacher's Resource Book are provided to help you create an environment in which students can interact with the information they learn for lasting understanding about the science of life. In addition, the resources in this book will facilitate creative course development by enabling you to supplement your course as you see fit. With the Teacher's Resource Book, you can meet the varied needs of all your students—from basic skill development and review to enrichment.

The Teacher's Resource Book contains seven types of handouts: review exercises, diagrams, study skills exercises, essays, laboratory skills fact sheets, problem-solving exercises, and taxonomy fact sheets.

The **Reviews** supplement the text end-of-section and end-of-chapter materials, providing questions to reinforce students' understanding of concepts and vocabulary presented in each chapter. Each review exercise is three pages long and is divided into two sections. The first section, *Reviewing Concepts and Vocabulary*, consists of recall questions and sentence completions. The second section, *Applying Concepts*, contains application questions, which are more challenging than the questions in the first section. You may want to use the *Applying Concepts* section only with your more capable students or in conjunction with teamwork and class discussion. Use the **Reviews** for chapter review prior to testing.

The **Diagrams** are based on illustrations in the text, but the art has been enlarged and simplified, and labels have been left off. These can be used for review, quizzes, tests, or to make overhead transparencies.

The **Study Skills** exercises emphasize basic skill development using a concrete approach. For each skill, the student is encouraged to carry out an activity. The exercises fall into three major groups: *Reading Skills*, *Science and Math Skills*, and *Visual Skills*. The exercises are best used when individual students need them. Alternatively, they can be used with an entire class during the first term so that students can put them to use during the remainder of the school year.

The **Essays** provide objective, up-to-date information on biosocial topics. Many of the essays present the difficult choices involved in resolving current problems. No clear-cut solutions are given; however, the essays should help students learn how to ask appropriate questions and to see what information is useful in searching for solutions. Each essay ends with questions for class discussion or further research. The **Essays** can be used with individual students or the entire class as a supplement to learning about related subjects in the text.

The **Laboratory Skills** fact sheets are one-page handouts that summarize basic techniques presented in the laboratory manual or provide supplementary information useful in lab and field work. The **Laboratory Skills** sheets can be posted in the lab or handed out for reference or relearning.

The **Problem-Solving** exercises are puzzles that can be solved only by applying biological knowledge. *Murder at the Zoo* involves classification. *The Case of the Hooded Murderer* is a problem in single-gene inheritance. *In the Teeth of the Evidence* combines paleontology and classification. *The Utopia Islands* is an example of evolution by natural selection. Use the **Problem-Solving** exercises after teaching the topics relevant to each.

The 30 **Taxonomy** fact sheets present the major characteristics and life histories of the most important groups of living organisms. They supplement and expand on the presentation in text Chapter 2, Classification of Living Things. The handouts can be taught as an additional unit after basic body systems and reproduction. Alternatively, use them to highlight discussion of taxonomic groups throughout the year or as a detailed reference for your students.

The **Answers** section at the end of the TRB contains answers for the **Reviews**, **Study Skills**, and **Problem-Solving** exercises.

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Diagrams

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Name ______________________ Date __________

Review Chapter 1 **The World of Life**

Reviewing Concepts and Vocabulary

1. ______________, the study of all living things, is sometimes divided into ______________, the study of animals, and ______________, the study of plants.
2. An individual living thing is called a(n) ______________.
3. What is a biological species?

____

4. The ______________ controls which substances enter and leave the cell.
5. What does the cell nucleus do?

____

6. In contrast to a unicellular organism, a multicellular organism has ______________.
7. List four functions that a unicellular organism must perform to survive.

____

____

8. Why must a unicellular organism perform more functions than a single cell in a multicellular organism?

____

____

9. The tendency to reduce the number of functions that something (such as a cell) performs is called specialization. What is the advantage of cell specialization?

____

10. Cells may be organized into ______________; organs may be organized into ______________.

Name ______________________________ Date ____________

11. ____________________ are conditions in the environment to which organisms respond.

12. What kind of reproduction involves only one parent? two parents?

____

13. Some organisms reproduce by sexual reproduction, others by asexual reproduction. In which case will the offspring more closely resemble the parent(s)? Why?

____

____

14. ____________________ is the study of interactions between organisms and their environment.

15. A biological community is made up of ____________________, ____________________, and decomposers.

16. A producer is the first step in a ____________________.

17. A ____________________ is a system of interconnected food chains.

18. What are the three basic environmental components that plants need for obtaining their food?

____

____

19. What kind of organism breaks down dead organisms and waste products into simple chemical substances?

____

20. ____________________ is the name for a close relationship between interacting organisms.

21. What type of organism feeds on other living organisms, on or in which it lives?

____

22. When organisms are in competition with each other, they ____________________

____

23. All the living and nonliving things in an area interact in a(n) ____________________.

Name ______________________ Date ____________

Applying Concepts

24. Why is biology considered a science?

____

25. Certain unicellular organisms live in groups, attached to other members of the same species. This may be the first stage in the development of multicellular organisms. What do you think would be the next stage in the development?

____

____

26. Life processes in plants and animals are controlled by both chemical signals and nerve signals. Which kind of signal do you think is faster? Why?

____

____

27. Consider this simple food chain:

grass ⟶ mice ⟶ fox

The mice eat the grass and are eaten in turn by the fox. What will happen if (a) there is a drought, and most of the grass dies? or if (b) a farmer kills the fox to protect his chickens?

____

____

____

____

28. Construct a food chain including humans and at least three other species.

29. Name an animal or plant and describe how it is adapted to its particular environment.

____

____

____

Name ______________________ Date __________

Review Chapter 2 **Classification of Living Things**

Reviewing Concepts and Vocabulary

1. How would you use a dichotomous key?

____

____

2. The name of a species may vary from place to place if the ______________ name is used, but its ______________ name is the same everywhere.

3. The science of naming and classifying organisms is ______________.

4. List in order the seven major categories of biological classification, from most specific to most general:

____

5. The system used to assign scientific names to organisms is called ______________.

6. What breeding characteristic identifies members of a species?

____

7. In using the scientific name *Parus hudsonicus*, the first word refers to the ______________; the second word refers to the ______________.

8. The ______________ classification system is based on five major groups of organisms, which are:

____

____

9. Bacteria and blue-green algae are in the ______________ kingdom.

10. What characteristic do bacteria and blue-green algae share? What is one major difference?

____

Name ______________________________ Date ______________

11. The ______________ kingdom is made up mainly of decomposers.

12. List the three chief characteristics of tracheophytes:

____

____

13. Tracheophytes can be divided into plants that produce ______________ and those that do not.

14. The kinds of animals that have been identified number ______________.

15. The only animals without nerve cells are ______________, which are classified in the ______________ phylum.

16. How is a mollusk's shell produced?

____

17. What three characteristics do most adult arachnids have in common:

____

____

____

18. In what ways are all arthropods alike?

____

19. The three characteristics all chordates have at some time in their development are:

____

____

____

20. What is the main characteristic of amphibians?

____

21. The skin of amphibians is ______________; in reptiles, it is ______________.

22. The only feathered animals are ______________.

Name ______________________ Date ____________

Review 2, page 3

Applying Concepts

23. Give examples of homologous structures and analogous structures:

24. Which are more closely related, animals with homologous structures or animals having analogous structures? Why?

25. How would you tell a plant from a fungus?

26. Some plants are better adapted to life on land than are others. Which plant phylum is best adapted to life on land? What are its adaptations?

27. Hydras and jellyfish have very different appearances. Why are they both classified as coelenterates?

28. Why are tunicates and lancelets in the same phylum with human beings (name the phylum)?

29. Classification of organisms is intended to reflect their evolution as well as their relatedness. One theory of the evolutionary development of the vertebrates can be shown as:

Fish → Amphibians → Reptiles → Birds
Reptiles → Mammals

What were the adaptations that improved the ability of each group to survive on land?

Name ______________________________ Date ____________

Review Chapter 3 **The Cell: Basic Unit of Life**

Reviewing Concepts and Vocabulary

1. ____________ built the first compound microscope; ____________ built the first simple microscope.
2. Explain how simple and compound microscopes differ.

   ____

   ____
3. How would you illuminate an object for observation with a light microscope?

   ____
4. The ____________ has greatly surpassed the light microscope in magnifying power; it is able to magnify biological materials up to ____________ times.
5. What is the main advantage of the phase contrast microscope?

   ____
6. The standard unit of measure in microscopy is the ____________.
7. The substance between the cell nucleus and the cell membrane is called ____________.
8. A hypothesis is ____

   ____
9. The term used to refer to the parts of a cell is ____________.
10. In an experiment, the ____________ is used for comparison against the ____________.
11. Specialization in multicellular organisms results in ____________ of ____________, which allows different body parts to perform different functions.

Name ______________________________ Date ______________

12. The fatty substances in cell membranes are called ______________.

13. What does a semipermeable membrane do?

____

____

14. The three kingdoms in which all the members have cell walls are:

____

15. Cellulose is a ______________ material found in the cell walls of ______________.

16. The largest and most important part of a eukaryotic cell is the ______________.

17. Substances pass between the nucleus and cytoplasm through ______________ in the nuclear membrane.

18. Chromosomes are made up of two chemical substances, ______________ and ______________.

19. What information is contained in the chromosomes?

____

____

20. Name four organelles found in cell cytoplasm and describe the function and characteristics of each.

____

____

____

____

21. Ribosomes are produced in the ______________, a structure found only in ______________ cells.

22. There are two types of endoplasmic reticulum: ______________ and ______________. Another organelle associated with the ER that functions in packaging of materials is the ______________.

Name ______________________________ Date ______________

Applying Concepts

23. The scanning electron microscope and the electron microscope both use electrons instead of light. How do these two types of microscope differ?

____

____

24. Why is it important to a cell membrane to be semipermeable?

____

25. Describe, or draw labeled diagrams of, the sequence of events in cellular digestion. Label the organelles and substances involved in this process.

26. Which do you think would contain more mitochondria, a muscle cell or a skin cell? Explain your answer.

____

____

27. Paramecia have microtubules in their cilia, as well as a network of microtubules throughout the cell. How does this organelle function in each case?

____

____

28. List the cellular organelles that are constructed of membranes:

____

____

29. Meat that is allowed to age before it is cooked becomes more tender. What might be happening inside the cells to cause this?

____

Name ______________________ Date ____________

Review Chapter 4 **The Molecular Machinery of the Cell**

Reviewing Concepts and Vocabulary

1. A(n) ____________, the smallest particle of an element, is composed of a ____________ containing ____________ and ____________, and surrounded by ____________.
2. Define the following terms:
   a. ion ____________
   b. compound ____________
   c. covalent bond ____________
   d. molecule ____________
3. When atoms react with each other and combine, they are held together by ____________.
4. What happens during a chemical reaction?

   ____
5. A ____________ is a machine that separates cell materials according to their weight.
6. ____________ is a method of molecular separation that is based on the different rates of movement of ____________ in solution across a special material.
7. A carbohydrate is composed of simple ____________, called ____________. Examples of these are ____________ and ____________.
8. Animals store carbohydrates in the form of ____________.
9. The basic units of a protein are ____________.

Name ______________________________ Date ______________

10. Define the following terms:

    a. unsaturated fat ______________________________

    b. polyunsaturated fat ______________________________

    c. saturated fat ______________________________

11. For each of the three major classes of organic compounds (fats, carbohydrates, and proteins), name a food containing it and say what it is used for when eaten.

    ____

    ____

    ____

    ____

12. A nucleotide consists of a ______________, a ______________, and a ______________.

13. Energy exists in two forms, kinetic and potential. How do they differ?

    ____

    ____

14. Activation energy is:

    ____

15. Catalysts in cells are called ______________; they are composed of ______________.

16. ______________ are compounds on which an enzyme acts; the results of an enzyme reaction are compounds, called ______________.

17. The process of forming large molecules from small molecules is called ______________.

18. ______________ is a type of synthesis that involves the splitting off of a water molecule at the site where a new bond is formed. The opposite of this process is ______________, in which a water molecule is taken up at the broken bond.

Name ______________________________ Date ____________

Applying Concepts

19. Write the structural formula for a water molecule, labeling the atoms:

20. When calcium carbonate is added to water it dissolves. The reaction can be written as: $CaCo_3 \rightarrow Ca^{++} + CO_3^{=}$ What kind of bond is being broken?

____

21. When proteins are heated, they lose their coiled structure. Why?

____

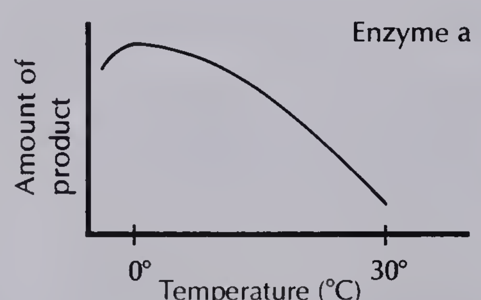
22. Explain the lock and key theory of enzyme function. Include a diagram.

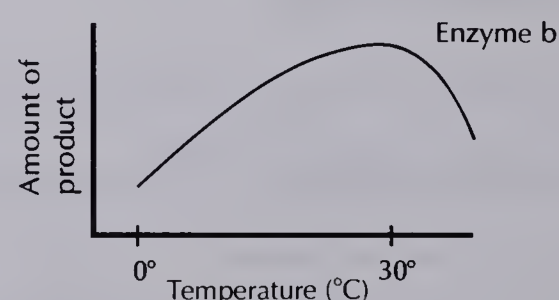
____

____

____

23. The graphs (below) represent two enzymes, one taken from an Arctic fish, the other taken from a laboratory rat. Both enzymes have the same function, but different temperature dependence. What is the optimal temperature for enzyme a? For enzyme b? Which enzyme comes from which animal?





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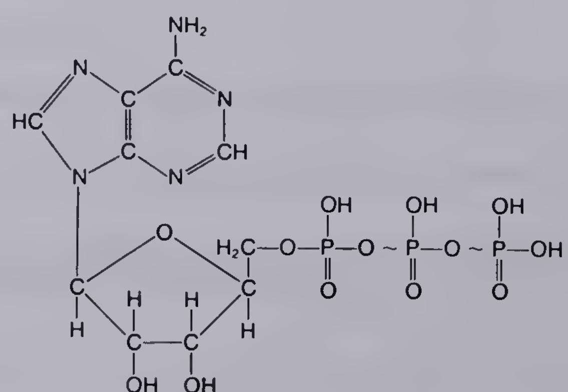
24. The addition of phosphates to adenosine results in the nucleotides AMP, ADP, and ATP. The structural formula below can be used to represent each of these. Use arrows to break the formula into the three molecules and label them with their spelled-out names.



Name ______________________________ Date ______________

Review Chapter 5 **Food Production and Nutrition**

Reviewing Concepts and Vocabulary

1. During the process of photosynthesis, ______________ and ______________ react to form the products ______________ and ______________.

2. The three cell layers making up a plant leaf are:

____

3. How is water transported to leaf cells?

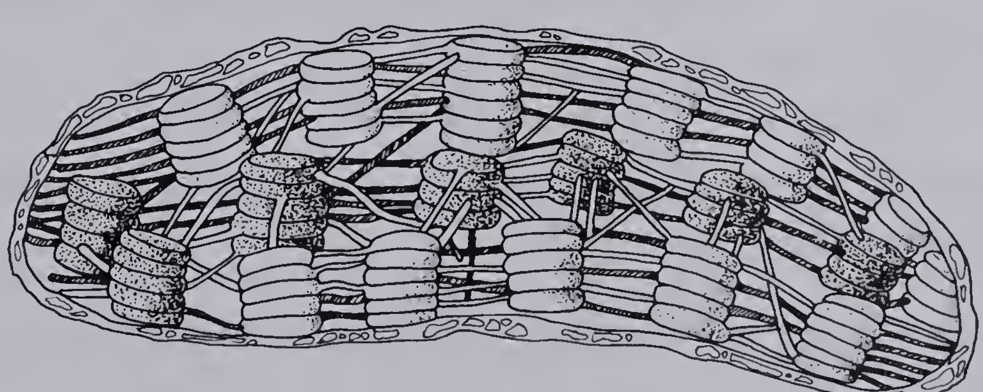
____

4 How are guard cells related to stomates?

____

5. The substance that colors plant leaves, flowers, and fruit is called ______________; it produces color by ______________ light.

6. The diagram is of a chloroplast. Label the thylakoid discs, grana, and stroma.



7. The two nucleotides that store light energy are ______________ and ______________.

8. The products of a reaction between ATP and water are: ______________ and ______________, plus energy.

Name ______________________________ Date ____________

9. The main function of NADPH is:

____

10. What causes an electron in a chlorophyll molecule to become "energized" or "excited"?

____

11. Name the five major classes of nutrients.

____

12. Nutrients may also be classified as essential or nonessential. How do they differ?

____

____

13. How many essential amino acids are there? Give an example of one.

____

14. An example of a disorder resulting from a vitamin deficiency is (name the vitamin):

____

15. Name two ways that water serves a vital function in the body:

____

16. The laboratory apparatus used to measure energy in food is called a(n)

____________________.

17. A Calorie is defined as:

____

18. Name two minerals, giving for each one a major function in the body, the results of a deficiency, and a food source:

____

____

____

____

19. Name three vital body functions that require basal metabolic energy.

____

Name ______________________________ Date ____________

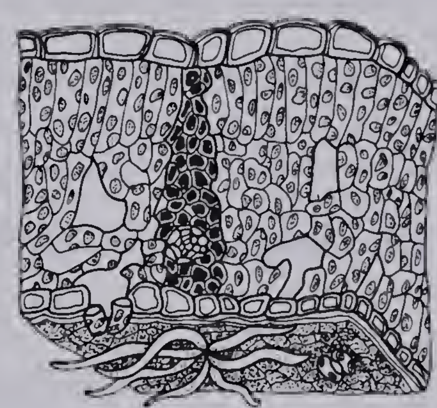
Applying Concepts

20. In Helmont's experiment the pot containing the willow sapling was sealed to prevent water loss directly from the soil. Yet, the soil continued to dry out; what was causing the water loss?

____

____

21. Refer to the drawing of a cross section through a leaf and label the various tissues. Where does most of the photosynthesis occur? Where will most of the $C0_2$ uptake occur?



____

____

____

____

22. How do plants reduce the rate at which they lose water? What does this do to the uptake of $C0_2$? What process is affected?

____

____

____

23. Complete the following table summarizing photosynthesis:

	Light reactions	*Dark reactions*
Energy source		
Inorganic compounds required		
Products		

24. Mammals and birds keep their body temperatures above that of their surroundings. Body temperatures of reptiles and fish vary with that of their surroundings. Which would you expect to have a higher metabolic rate? Why?

____

____

Name ______________________ Date __________

Review Chapter 6 **Obtaining Energy from Food**

Reviewing Concepts and Vocabulary

1. Cellular respiration is the process by which organisms obtain ______________ from ______________.
2. What happens to the energy released during cellular respiration?

____

3. Identify the energy source used to make ATP in photosynthesis and in cellular respiration.

____

____

____

4. A biochemical pathway is:

____

5. The three main stages of cellular respiration are:

____

6. How does the first stage of cellular respiration differ from the others?

____

7. The ______________ is the cell organelle in which two stages of cellular respiration occur; it contains shelflike structures called ______________.
8. Fermentation, an ______________ form of cellular respiration, does not require ______________.
9. What happens to glucose molecules during glycolysis?

____

10. During the citric acid cycle molecules of citric acid are broken down, releasing ______________ and producing ______________.

Name ______________________________ Date ____________

Review 6, page 2

11. As energized electrons are passed from one carrier molecule to the next during electron transport, the electrons ____________ energy, which is used to make ____________.

12. Fill in the blanks in the equation below summarizing cellular respiration:

$$C_6H_{12}0_6 + 6 \_\_ + 36 \_\_ \rightarrow 6C0_2 + 6 \_\_ + 36 \_\_.$$

13. The process of fermentation produces ____________ in muscle cells, and ____________ and ____________ in yeast.

14. During aerobic respiration ____________ ATP molecules per glucose molecule are produced. This number is ____________ than that produced during anaerobic respiration.

15. Lipids, carbohydrates and proteins each yield different amounts of energy during cellular respiration. Which of these three nutrients yields twice the energy per gram as either of the other two? How is this nutrient stored?

____

16. Metabolism is a broad term for:

____

17. The higher the metabolic rate, the more ____________ an organism is and the more ____________ it consumes.

18. Metabolism is affected by an animals' size and physiology. What relationship is there between basal metabolic rate and body size in mammals?

____

____

19. How do certain mammals slow down their metabolic rate in cold weather?

____

20. Reptiles, amphibians, fish, and insects are termed "coldblooded"; what does this term mean with regard to metabolic rate? Give one example.

____

____

____

Name ______________________________ Date ____________

Applying Concepts

21. Heat is a byproduct of the controlled breakdown of nutrients. What effect does it have on chemical reactions? In what form do cells harness energy to make it useful?

____

____

22. How are photosynthesis and respiration similar but opposite processes? Discuss sources of energy, products, and organelles involved in each.

____

____

____

____

____

____

23. If a mouse is placed in a sealed container, it soon dies. Why?

____

a. If many plants are also in the container, will the mouse live a longer or shorter time?

____

b. If an opaque cloth is now placed over the entire container, how will the experiment be affected?

____

Explain your answers:

____

____

24. What do all warmblooded aquatic animals, such as seals and whales, have in common that aids in maintaining body heat and stores energy?

____

Name ______________________ Date __________

Review Chapter 7 **Gas Exchange**

Reviewing Concepts and Vocabulary

1. Three closely related processes are respiration, cellular respiration, and breathing. Define each term:

____

____

____

2. List four steps involved in respiration:

____

____

____

____

____

3. The ______________ are openings on a plant leaf surface through which liquids and gases move in and out.

4. The amount of oxygen and carbon dioxide moving into or out of a leaf are related to two processes in a plant, ______________ and ______________.

5. How is a stomate formed and what causes it to open?

____

____

____

6. Why is the process of gas exchange in roots simpler than in leaves?

____

7. Describe respiration in the hydra.

____

____

Name ______________________________ Date ____________

8. In the earthworm, gas exchange occurs across its ______________, which is kept moist by a secretion of ______________.

9. The grasshopper breathes through pairs of ______________ along its side; these connect to a system of tubes called ______________. Air is pumped in and out by ______________ ______________ and by movements of the body wall.

10. A major function of red blood cells is:

____

11. Red blood cells contain the pigment ______________, which carries ______________ in the blood.

12. Define homeostasis. How is this term applied to the process of respiration?

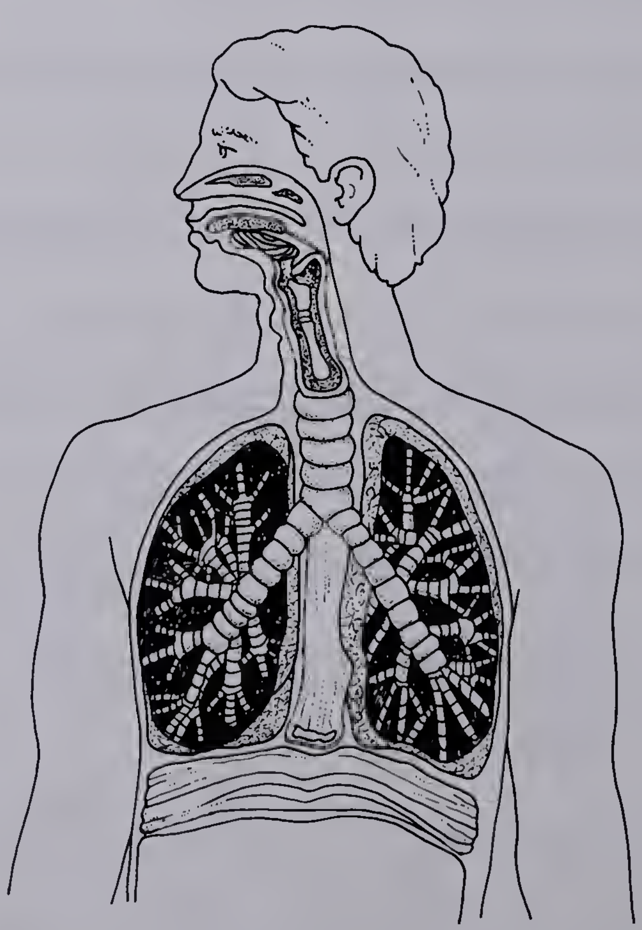
____

____

____

13. The ______________ centers in the brain respond to the level of ______________ in the blood.

14. Label the parts of the human respiratory system in the diagram:



Name ________________________________ Date ____________

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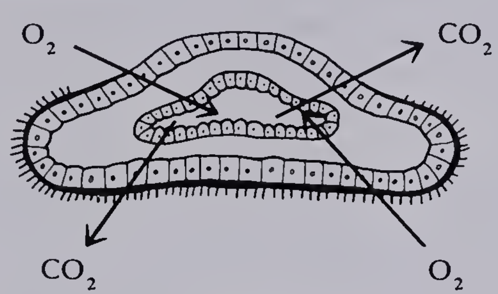
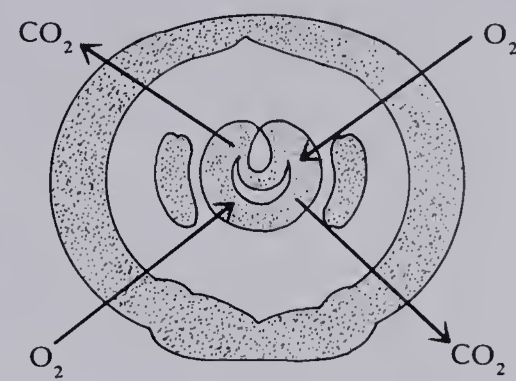
Applying Concepts

15. One of the biggest problems of respiration in a multicellular animal is getting oxygen to the center of the body and removing carbon dioxide from it. The drawings represent cross sections of two kinds of worms.



Platyhelminth



Annelid

a. In which worm do gases have farthest to travel? How is this worm adapted for the most efficient gas exchange?

____

____

b. Which worm has more surface area for gas exchange?

____

16. Explain the mechanism by which carbon dioxide and oxygen are transferred between alveoli and capillaries:

____

____

____

17. Which would you expect to use more oxygen in proportion to its body size, a warmblooded animal or a coldblooded one? Which will require a larger surface area for gas exchange?

____

____

18. Gas exchange in a plant varies, depending on whether stomates are open or closed. On a hot, dry day would you expect the stomates to be open or closed? Why? What effect will this have on the rate of photosynthesis?

____

____

Name ______________________ Date __________

Review Chapter 8 **Food Processing**

Reviewing Concepts and Vocabulary

1. List the five steps used by consumers in processing food:

____

____

____

____

____

2. An ameba's food cavity is its ____________ ____________;
in humans it is the ____________ ____________.

3. The process of taking food into the body is called ____________.

4. Compare mechanical digestion and chemical digestion.

____

____

____

____

5. For each of the following name a type of enzyme used in their breakdown:

   a. proteins ____________ c. carbohydrates ____________

   b. lipids ____________ d. nucleic acids ____________

6. What are the end products of digestion of:

   a. starch? ____________

   b. maltose? ____________

   c. proteins? ____________

   d. lipids? ____________

   e. nucleic acids? ____________

7. ______________ digestion, such as is found in the ameba, takes place within a cell. In animals having a digestive tract ______________ digestion is the chief form of chemical digestion.
8. The process of ______________ allows digested food to be distributed to all parts of the body. Undigested material leaves the body through the process of ______________.
9. The paramecium uses cilia to sweep food particles into its ______________ ______________; undigested material is expelled through its ______________ ______________.
10. The hydra has stinging cells on its tentacles, called ______________. How are they used?

    ____

11. In the earthworm, food moves through the esophagus into the ______________, a food storage organ; food then enters the ______________ before entering the ______________, where chemical digestion takes place.
12. After ______________ digestion takes place in the grasshopper's gizzard, food moves to the ______________ where ______________ digestion is completed, and absorption takes place.
13. The six major parts of the human digestive tract are:

    ____

14. The three types of digestive secretions that enter the small intestine are:

    ____

15. Absorption in the small intestine is aided by the ______________ of the cells lining the intestine.
16. The digestive system is controlled in two ways, by ______________ and by ______________.

Name ______________________________ Date ____________

Applying Concepts

17. Many parasites that live in their hosts' blood or gut have no digestive systems of their own. How can they survive?

____

18. Spiders and some insects cannot eat solid food. Their mouth parts are like hollow needles through which they can inject a liquid into their prey, then suck out the nutrient-rich liquids. What do you think the injected liquid might contain?

____

19. In mosquitoes, only the female sucks blood, and she does so at about the time she is ready to produce eggs. The males live on plant juices that contain almost no protein.

    a. Why do you think the female requires a blood meal?

    ____

    b. What food substance can the male get from plants?

    ____

20. Why is the earthworm's digestive system more efficient than that of the hydra?

____

____

____

21. Substances that neutralize stomach acids are used for treating ulcers. What effect might this have on digestion? Digestion of which foods would be most affected?

____

____

22. Would you expect a rabbit or a cat to have the larger digestive tract relative to its size? Explain.

____

____

23. If the nerves running from the stomach to the brain of an experimental animal are cut, what effect do you think this might have on the eating habits and body weight of the animal? Explain.

____

____

Name ______________________________ Date ____________

Review Chapter 9 **Transport**

Reviewing Concepts and Vocabulary

1. Diffusion is defined as the movement of substances from a place of

   ________________ concentration to a place of ________________

   concentration.

2. Osmosis is defined as the ________________ of water across a

   ________________ membrane.

3. If a red blood cell is put into a solution with a very high concentration of sugar, it will (circle the correct letter):
   a. expand and burst.
   b. shrivel up.
   c. retain its shape.
   d. reduce its internal sugar concentration.

4. Bean roots absorb water by ________________ transport and minerals by

   ________________ transport. The concentration of ________________

   inside the root is ________________ than the concentration of

   ________________ outside it.

5. What three processes are believed to be involved in moving water from the roots to the leaves of a tall plant?

   ____

   ____

   ____

6. For each of the following, state whether the circulatory system is open or closed.

   a. earthworm ________________ c. human ________________

   b. grasshopper ________________ d. fish ________________

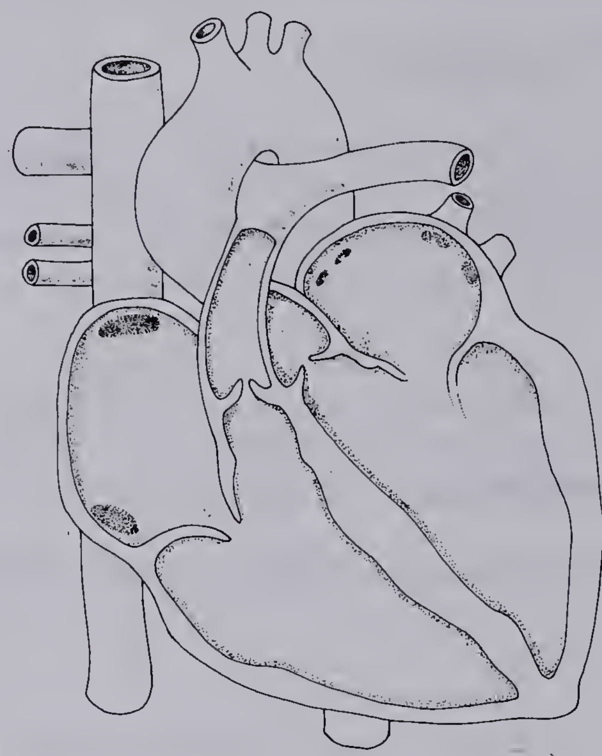
7. In which of the following structures would you expect to find valves (write *yes* or *no*)?

   a. heart ________________ c. veins ________________

   b. arteries ________________ d. capillaries ________________

Name ______________________ Date ____________

8. This diagram is of the human heart. Add labels to indicate the following: direction of flow of blood (use as many arrows as necessary), right and left ventricles, right and left atria, pulmonary arteries, pulmonary veins, aorta, vena cavae.



9. Draw lines matching the events in the left column with the resulting change in circulation listed in the right column.

a. rise in body temperature	increased heart rate
b. exercise	dilation of skin capillaries
c. eating	dilation of arteries and decreased heart rate
d. excessively high blood pressure	dilation of arteries to gut

10. What two systems are directly involved in controlling the heartbeat?

____

Applying Concepts

11. Most of the processes that control circulation are interrelated. For example, during exercise the capillaries in the skin usually dilate, although this will not affect muscle performance. Why does this happen?

____

____

____

____

____

12. Why is the transport system considered a life-support system in complex organisms?

13. The mammalian circulatory system is termed a double circulatory system because blood passes through the heart twice in completing one circuit through the body. Why is a double circulatory system more efficient than a system in which blood circulates once (as in a fish: from heart to gills to body and back)?

14. A tree has been described as an oasis in a desert of air. Describe at least two ways in which this description is accurate.

Name ______________________________ Date ____________

Review Chapter 10 **Excretion**

Reviewing Concepts and Vocabulary

1. Most nitrogenous wastes are produced during the breakdown of

   ____________________.

2. Complete the following table:

Type of nitrogenous waste	Toxicity (high, medium, low)	Solubility in water (high, medium, low)	Example of an organism that excretes this type of waste
Ammonia			
Urea			
Uric acid			

3. Reptiles, insects, and birds excrete ____________________ ____________________, which has the advantage of being relatively insoluble and can therefore be excreted with very little loss of ____________________.

4. Cells produce carbon dioxide during respiration. This dissolves in water to form ____________________ ____________________. As this accumulates in cells, they become more ____________________; too much of this substance will interfere with ____________________ function.

5. Fish living in the sea tend to ____________________ water by osmosis; freshwater fish tend to ____________________ water by osmosis. Bony marine fish do not become dehydrated from drinking sea water because they are able to ____________________ salt through their gills. Freshwater fish excrete ____________________ amounts of urine; some are able to ____________________ salts through their gills.

Name ______________________________ Date ______________

6. When photosynthesis is not taking place bean plants excrete ______________.

7. Two ______________ ______________ enable the paramecium to excrete excess ______________.

8. The earthworm has pairs of excretory organs on most body segments, called ______________.

9. In the grasshopper, excretion takes place in the ______________. Water enters these organs by ______________; uric acid and waste salts enter by ______________ ______________.

10. The human excretory system includes the ______________, which excrete carbon dioxide. ______________, ______________, and ______________ are excreted by the skin. The major organs of excretion are the ______________, which produce ______________.

11. Antidiuretic hormone is secreted as a result of a lowered level of ______________ in the blood. ADH acts to stimulate kidney tubule cells to become ______________ to water; as a result, ______________ water is reabsorbed into the blood and the urine becomes more ______________.

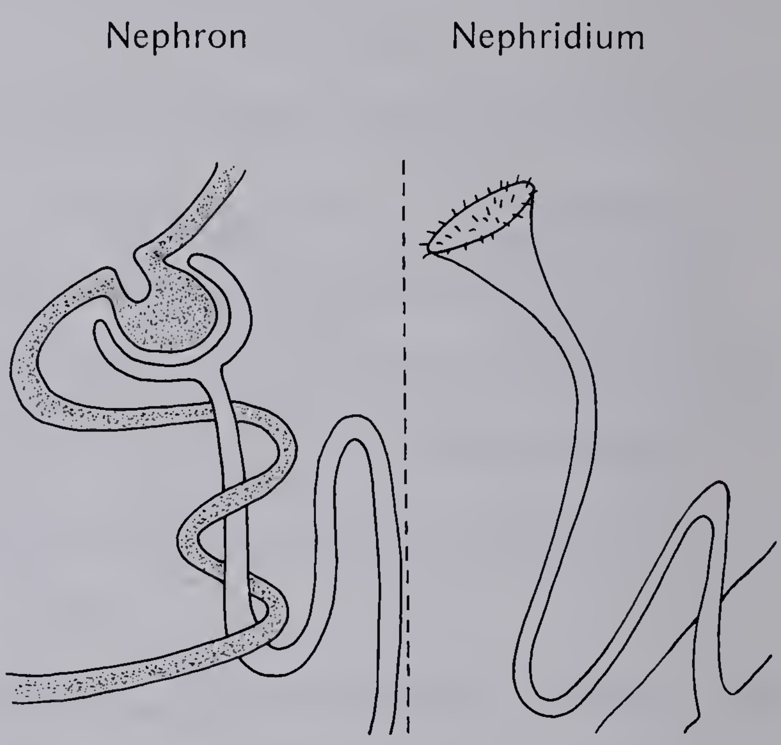
Applying Concepts

12. Sharks and rays live in the sea, but they lack the systems of bony fish that regulate salt and water balance. Instead, their blood has a much higher concentration of urea—10 to 15 times as high as in bony fish. Explain how this helps sharks and rays to survive.

Name ______________________________ Date ____________

13. Why do plants excrete carbon dioxide at night but not during the day?

14. The nephron in the vertebrate kidney and the nephridium in the earthworm both work in very similar ways.



a. Are these structures analogous or homologous? (Compare the diagrams). Explain your answer.

b. For the two tubules, label arrows to indicate the pathways followed by each of the following: protein, urea, salts, water, glucose, and penicillin.

c. There is little, if any, protein in the body fluid of the earthworm; there is protein in the blood of a vertebrate. What adaptations in the structure of Bowman's capsule and the nephridium reflect this difference between earthworms and vertebrates?

d. In the earthworm, cilia are used to drive body fluid into the nephridium. How do wastes enter the vertebrate kidney?

Name ______________________ Date __________

Review Chapter 11 Movement and Locomotion

Reviewing Concepts and Vocabulary

1. Most cellular movement and locomotion depends on special ______________ in the cell that produce movement by ______________.
2. The internal structure of cilia and ______________ consist of nine pairs of ______________ arranged in a ring, with two ______________ in the center.
3. Name an organism that:
   a. uses cilia to propel itself: ______________
   b. uses flagella for locomotion: ______________
   c. uses flagella to capture food: ______________
4. The ameba moves about by producing extensions of its cytoplasm, called ______________.
5. Plants do not move in the same way as animals. How do plants move?
   ____
   ____
   ____
6. In animals without a hard skeleton, such as the earthworm, what do the muscles pull against?
   ____
7. The hydra's movement and locomotion are under the control of specialized ______________ cells; they stimulate ______________ fibers located in the ______________ and ______________.
8. In the earthworm, the longitudinal muscles ______________ the body; when the circular muscles contract, the body ______________.

9. The grasshopper is capable of a wide variety of movements; muscles are attached to the exoskeleton covering each of its three body parts: ______________,

______________, and ______________.

10. The human skeleton is made up of two parts, the bones of the skull, backbone, and ribs, and the bones that make up the ______________.

11. The human skeleton is composed of a variety of tissues having different physical properties and different functions. Complete the following table:

Skeletal material	Physical properties	Structure in which it is found
Bone, spongy	very light; has many spaces	ends of long bones
Bone, compact		
Cartilage		
Ligament		
Tendon		

12. Classify the muscle types listed below according to three properties: striated/unstriated, voluntary/involuntary, and slow/fast contraction:

Skeletal: ______________ ______________ ______________

Smooth: ______________ ______________ ______________

Cardiac: ______________ ______________ ______________

13. Cardiac muscle has a very high density of mitochondria and an extremely rich blood supply. How do these help to maintain its activity?

____

____

14. Skeletal muscle contracts in response to stimulation by ______________.

Cardiac and smooth muscle are controlled by ______________ and

______________.

Name ______________________________ Date ____________

Review 11, page 3

Applying Concepts

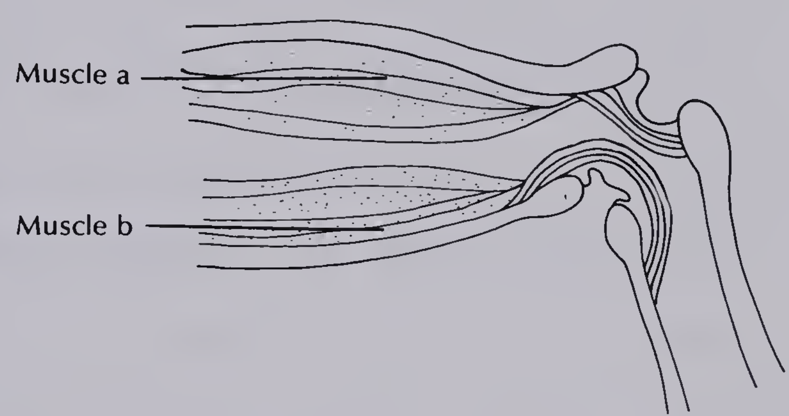
15. Why do muscles switch to anaerobic respiration during heavy exercise? How is it that continued muscle use can result in muscle fatigue?

____

____

____

16. This diagram represents a joint from an animal:



   a. What kind of skeleton does the animal have?

   ____

   b. What kind of animal could this be?

   ____

   c. Which muscle acts as a flexor? ____________________

   d. Which muscle acts as an extensor? ____________________

17. A skeleton that encases an animal protects the animal's tissues and prevents water loss or uptake. These skeletons have two disadvantages. What are they? What adaptation is related to one of these disadvantages?

____

____

____

18. Spiders have a very interesting arrangement of muscles. They have only one set of muscles in their legs, which bend the legs. Their bodies are rather soft, and they have muscles that can decrease the abdominal volume. The fluid-filled spaces of the body and legs are interconnected. How do you think a spider's legs might be extended?

____

____

19. Patients suffering from blood diseases are occasionally treated with transplants of bone marrow. Why?

____

____

Name ______________________________ Date ____________

Review Chapter 12 **Chemical Control**

Reviewing Concepts and Vocabulary

1. What are hormones?

____

____

2. Hormones are delivered in three steps. Briefly describe these steps:

____

____

____

____

____

3. Hormones in complex plants are produced by specialized cells in the ______________ regions of the plant.

4. Two plant hormones that interact to promote growth of roots, stems, and leaves are ______________ and ______________. A growth-inhibiting hormone is ______________, which acts at the base of ______________ and ______________ stalks, causing them to ______________.

5. If the concentration of ______________ is the same in all parts of the stem, the stem grows straight up; the production of this hormone is inhibited by ______________.

6. Endocrine glands are ______________ glands; they release hormones directly into the ______________ cells.

7. Protein hormones bind to receptors in the ______________ of their target cells. Steroid hormone receptors are located ______________ their target cells.

8. As a protein hormone reaches a target cell, it is ______________ by receptor molecules. After the hormone and receptor combine, a molecule of ______________ forms and acts as a ______________ ______________ that enters the cell and performs the regulating function of the hormone.

9. In insects, ______________ is largely controlled by ______________ hormone and juvenile hormone.

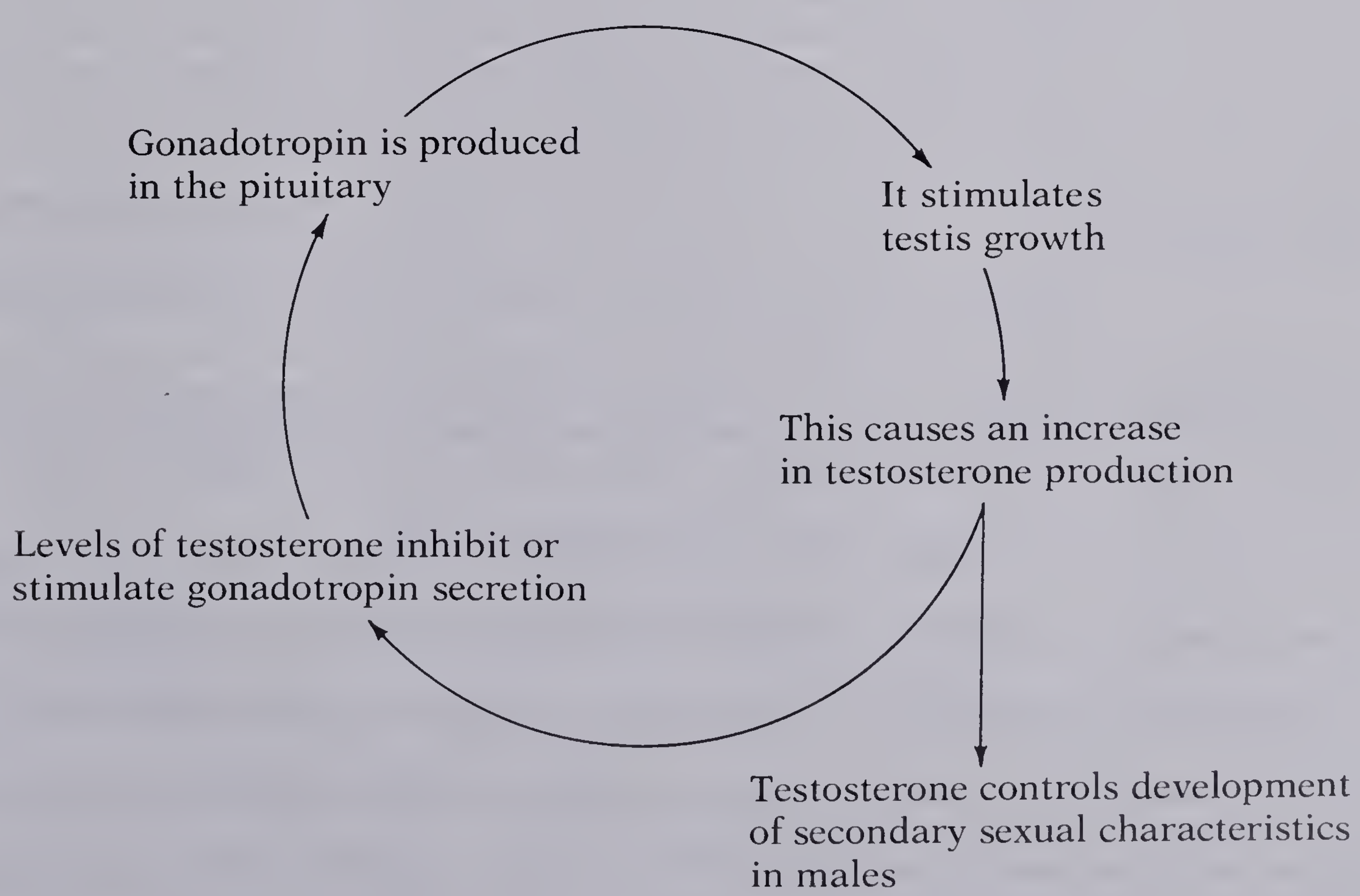
10. The menstrual cycle has three main stages. List them in their correct sequence.

____

11. The last stage of the menstral cycle is followed either by ______________ or ______________.

Applying Concepts

12. Hormone levels in animals are often controlled by ______________ mechanisms. Consider the following example:



In most male mammals, if one testis is removed sperm production eventually recovers to the pre-operational level. List the series of events that leads to this recovery.

13. Explain why a person who has the disease *diabetes mellitus* could show symptoms of dehydration and starvation. What treatment is used to correct this condition?

14. Discuss three of the hormones that act during pregnancy, where they are produced, and what effects they have:

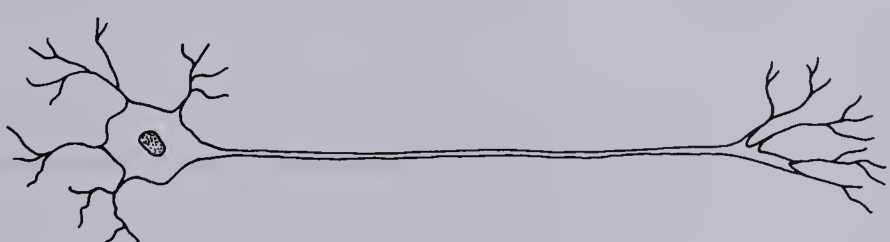
15. Discuss what events must occur immediately after an egg is fertilized for a pregnancy to begin:

Name ______________________________ Date ______________

Review Chapter 13 **Nervous Control**

Reviewing Concepts and Vocabulary

1. A receptor is a kind of ______________ that picks up information about an organism's internal or external ______________.
2. Information from a receptor is transmitted to a(n) ______________, the part of an organism that responds.
3. On the diagram, label the (a) dendrites, (b) cell body, (c) axon, (d) end fibers, and (e) direction that a nerve signal travels.



4. ______________ neurons transmit impulses from receptors.

   ______________ neurons transmit impulses to effectors.

   ______________ transmit impulses between other neurons.
5. A neuron in its resting state has a ______________ concentration of sodium ions inside the neuron that outside it; the concentration of positive ______________ ions and ______________ -charged ions and protein molecules is higher inside the cell. In effect, the inside of the membrane is ______________ charged with respect to the outside.
6. When a sufficiently strong stimulus reaches the dendrites of a neuron, the permeability of the cell membrane to ______________ ions increases. The resulting flow of these ions into the cell makes the inside ______________ charged with respect to the outside. As this change in charge occurs at successive points along the membrane a ______________ ______________ is transmitted.

Name ______________________ Date __________

7. How does the nervous system of a hydra or sea anemone differ from that of vertebrates and complex invertebrates? What effects does this have on the hydra's behavior?

____

____

____

____

____

8. Describe how a wave of muscular contraction is produced down the length of the earthworm.

____

____

____

____

____

9. As in the earthworm, voluntary control of body movements in the grasshopper occurs mainly in the two large ______________, a kind of brain.

10. The autonomic nervous system exerts ______________ control over the vital organs. Give three examples of body processes controlled by this system:

____

____

11. Sympathetic nerves produce noradrenalin at their synapses. Parasympathetic nerves produce ______________ at their synapses.

12. The sympathetic/parasympathetic nervous systems have ______________ effects on organs; one acts to ______________ ______________ while the other acts to ______________ ______________ the activity of the organ.

13. The relationship that exists between muscle fiber and motor neurons that enables quick muscle movement is called a ______________ ______________.

Name ______________________________ Date ______________

Applying Concepts

14. Two neurons are linked by a synapse in which the transmitter substance is acetylcholine. If an inhibitor of the enzyme cholinesterase is added, what will happen:
    a. to the amount of acetylcholine released in response to an impulse?

    ____

    b. to the levels of acetylcholine present in the synapse after an impulse?

    ____

    c. to the permeability of the neuron membrane to sodium ions?

    ____

    d. to the rate and duration of impulse initiation in the second neuron following an impulse in the first neuron?

    ____

15. To test your reflexes, a doctor will tap your leg just below the knee. This stimulates the stretch receptors there and, through a simple reflex arc, leads to a twitch in the extensor muscle. Draw and label a diagram showing all the components of this reflex arc.

16. What mechanism within the neuron prevents the membrane from becoming neutralized? How does it work?

    ____

    ____

    ____

    ____

Name ______________________________ Date ____________

Review Chapter 14 **The Senses**

Reviewing Concepts and Vocabulary

1. Match each receptor type with the stimulus it detects.

mechanoreceptor	body movements or position
photoreceptor	heat
thermoreceptor	light
proprioceptor	touch, pressure, vibration

2. Humans can detect only part of the light spectrum and can hear a certain range of sound waves. Name two stimuli that can be detected by some animals but not by humans. Give examples of animals that can detect each.

____

____

3. A stimulus causes a ______________ in a receptor; this, in turn, triggers a nerve impulse in a nearby ______________. What determines the type of response produced by a stimulus?

____

4. Bats and humans hear different ranges of sound. Which is capable of detecting higher frequency sounds? How do bats locate prey in the darkness?

____

____

____

5. What advantage is it to bees to be able to detect the plane of polarization of light?

____

____

6. The ears of a moth, a grasshopper, and a human are alike in having a ______________ ______________, which is the first structure of the ear to vibrate in response to sound waves.

Name ________________________ Date ____________

7. The hammer, ______________, and ______________ are three bones in the ______________ ear that conduct vibrations to a membrane in the ______________ ear, called the ______________ ______________.

8. In what structure in the ear are vibrations converted to nerve impulses? How are they conducted to the brain?

____

9. A simple eye has a ______________ which gathers light and focuses it on light receptor cells. A ______________ eye is made up of many small surfaces called ______________, each of which is the lens of a tubelike structure called an ______________. How does vision differ in each of these eye types?

____

____

10. A vertebrate eye has been described as a camera-type eye. Explain why.

____

____

11. The human eye is composed of three layers: the outside layer, the ______________, has a rounded transparent part at the front of the eye called the ______________. What happens to light entering this last structure?

____

12. Both smell and taste are detected by receptors called ______________. Taste perception aids in survival by providing information about substances that could be harmful if eaten. For this reason most animals avoid eating substances that are ______________ tasting.

13. The ______________ of the human eye contains two kinds of light-sensitive cells. Which do you use in bright light? Which in dim? In what way is our perception of the visual world different in dim light?

____

Name ______________________ Date ____________

Applying Concepts

14. On moving from bright light to dim light, you may have difficulty seeing for a while. What is happening during the period of adjustment to the change?

15. Snakes that feed primarily on such animals as amphibians or reptiles do not have thermoreceptive pits. Why not?

16. Relatively speaking, which animal would you expect to have larger areas of the brain, by proportion, devoted to analyzing sensory information from the organs of smell, a fish or a human being? Why?

17. By spinning around several times, you can make yourself dizzy. What do you think happens to the fluid in your semicircular canals when you do this?

18. When the skin touches something very hot or very cold, the immediate sensation is the same. Why?

19. Some spiders catch their prey in webs, but others (sometimes called wolf spiders) chase their prey and may jump as far as a metre to catch them. Which type of spider would you expect to have better vision? Why?

Name ______________________________ Date ____________

Review Chapter 15 **Reproduction of Molecules and Cells**

Reviewing Concepts and Vocabulary

1. The four ______________ bases in the DNA molecule are adenine, cytosine, ______________, and guanine.

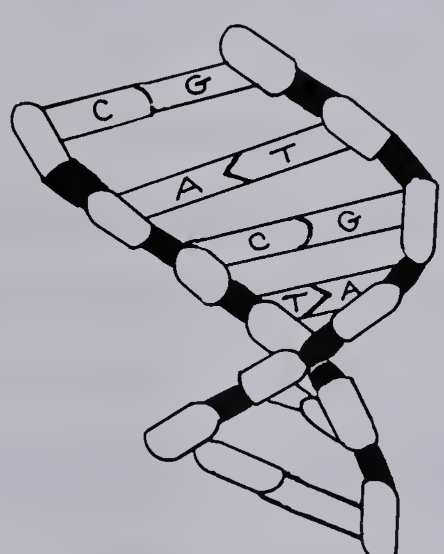
   a. Which of these bases pair with each other?

   ____

   b. Which of these bases is replaced in the RNA molecule, and by what?

   ____

2. The diagram represents a piece of DNA. Draw a nucleotide based on this diagram, labeling the base, the simple sugar, and the phosphate group:



3. The double-spiral shape of the DNA molecule is known as a ______________ ______________. Explain briefly what happens during DNA replication:

   ____

   ____

   ____

   ____

Name ______________________________ Date ____________

4. Match the phases of mitosis with their events. Then, number the phases to put them in the correct sequence.

________	Telophase	Chromosomes consolidate, spindle forms
________	Anaphase	DNA replicates
________	Metaphase	Cytoplasmic division, chromosomes unravel
________	Prophase	Chromosomes line up at middle of spindle; centromeres divide
________	Interphase	
		Chromosomes separate into two sets

5. ______________ division results in the separation of the two nuclei into separate cells. In plant cells a structure called the ______________ ______________ forms between the two nuclei.

6. Uncontrolled cellular division may result in the condition of ______________.

7. Proteins are made up of ______________ of amino acids. Information for building proteins is stored in the coded message in ______________.

8. Three types of RNA are involved in protein synthesis (spell out):

______________ RNA, ______________ RNA, and ______________ RNA. Which has the initial role of carrying the triplet code information from DNA? What is the next function of this RNA molecule in protein synthesis?

____

____

____

9. Along which organelle does protein synthesis take place? Explain how tRNA and mRNA interact to build proteins:

____

____

____

____

10. Complete the following table comparing DNA and RNA nucleotides:

	DNA	RNA
Number of strands:		
Simple sugar:		
Nitrogen base not shared:		
Area of the cell where usually found:		

Applying Concepts

11. In a 70-year-old person, how old would you expect a nerve cell to be? An intestinal cell?

____

12. If the mechanisms for replicating DNA and for using the DNA code to synthesize proteins were unreliable and produced many mistakes in copying, in what ways would an organism be affected?

____

____

____

____

13. Complete the following diagram of base triplets, from DNA to mRNA sequences:

Original DNA sequence $\longrightarrow$	mRNA sequence
G	______
C	______
A	______
A	______
T	______
G	______

Name ______________________ Date __________

Review Chapter 16 **Reproduction of Organisms**

Reviewing Concepts and Vocabulary

1. In ____________ reproduction, there is only one parent.

2. ____________ reproduction involves the fusion of two ____________ to form a ____________.

3. Which form of reproduction will produce offspring that are most similar to their parents and to each other? Why?

   ____

4. Match each description with the correct term and give an example of an organism for each type of reproduction.

		Example
Development of new individuals from pieces of the parent	Binary fission	________
Division of a single cell into two identical offspring.	Budding	________
Development of offspring from unfertilized eggs.	Spore formation	________
Development of smaller, but otherwise similar, offspring as outgrowths of a single parent.	Parthenogenesis	________
Production by mitosis of a large number of small reproductive cells that develop into new organisms with the same DNA as the parent.	Fragmentation	________

5. J. B. Gurdon produced an artificial ____________ of frogs from the intestinal cells of one parent frog.

6. Asexual reproduction is based on mitosis. Sexual reproduction requires a different form of cell division. What is it? How does it differ from mitosis?

   ____

   ____

   ____

7. In sexual reproduction the offspring have the same, ____________ number of chromosomes as their parents. Gametes produced by each of the parents have the ____________ number of chromosomes.

8. Pairing of homologous chromosomes is called ____________.
____________ is the process of exchange of parts between two homologous chromatids. It occurs in the ____________ meiotic division, during ____________. Another term for this process is ____________.

9. The effect of recombination is to (circle one letter):
   a. increase the genetic variability of a population.
   b. decrease the genetic variability of a population.
   c. have no effect on the genetic variability.
   d. tend to remove unwanted mutations from a population.

10. Gametes that look alike are called ____________. Most species produce gametes that are different in size and shape, called ____________.

11. Male animals produce gametes called ____________; they are produced in reproductive organs called ____________. Likewise, female animals produce ____________ in their ____________.

12. Explain in general terms the process of fertilization:

____

____

13. Both oogenesis and spermatogenesis involve the process of ____________ followed by ____________ of the cells into eggs or sperm.

14. How does sexual reproduction result in offspring having variations? What causes variations to appear in species that reproduce asexually?

____

____

15. Why do organisms that rely on external fertilization produce more gametes?

____

____

Name ______________________________ Date ____________

Applying Concepts

16. Mosses and ferns produce spermlike gametes that swim to the female reproductive organ. Why are such plants limited to damp environments?

____

____

17. Plant and animal species in which individuals produce both types of gametes often have adaptations that prevent self-fertizilization. Why?

____

____

18. Why is internal fertilization usually found in terrestrial organisms?

____

____

____

19. One of the most important applications of biology is the breeding of new strains of maize and wheat in order to increase food production. Why do these breeding programs depend on the ability of these plants to reproduce sexually?

____

____

____

20. In monitoring the ecosystem of a pond, some scientists found two species of protists that they suspected were reproducing in different ways. Each summer the level of water in the pond dropped, and the saltiness of the water increased. This caused some protists of species A to die, but all of species B survived. During one summer there was a drought, and the salt content of the water rose to a much higher level than usual. Species B was wiped out, but a few individuals of species A survived. If tolerance of salty water is genetically controlled, which population is more likely to be composed of clones? Explain your answer.

____

____

____

____

6. ______________ is the time period between fertilization of the egg and birth.

7. List the three membranes that form around an embryo and give a function of each:

____

____

____

8. ______________ ______________ is the process whereby one tissue in an embryo contacts another and affects its development.

9. The ______________ ______________ is a bulge separating the embryo into left and right sides; it later develops into the ______________ ______________.

10. The three periods of pregnancy, or ______________, each lasts ______________ months. In which of these periods does most development of nervous tissue take place? During which period does the embryo become a fetus?

____

11. If two eggs are released at the same time and both are fertilized, the resulting offspring are ______________ twins. If the zygote divides and each cell develops into an embryo, the offspring are ______________ twins. Which twins are more alike? Why?

____

____

12. During labor rhythmic contractions of smooth muscles in the wall of the ______________ cause the ______________ to dilate. Once the baby leaves the uterus, it passes through the birth canal, or the ______________. What is the afterbirth?

____

13. For mating to occur, the male and female of a species must first find each other. Give two examples of adaptations that bring vertebrate males and females together:

____

Name ______________________ Date __________

Review 18, page 3

Applying Concepts

14. Reptiles and amphibians both lay eggs. What feature of their eggs allows reptiles to lay them on land? In which of these two animals would you expect to find internal fertilization? Why?

15. The chorion and allantois that surround the chick embryo, and the placenta associated with the mammalian embryo have a similar function. What is it?

16. Why do chick embryos store nitrogenous waste as uric acid instead of urea?

17. Animals that have internal fertilization produce far fewer eggs and sperm, and fewer offspring, than those having external fertilization. How do they compensate for this?

18. Why do marsupials have shorter gestation periods than do other mammals?

19. What are the two basic adaptations that ensure offspring survival? Which is common in birds and mammals? It is theorized that this adaptation may have contributed to increased intelligence in primates over time. What do you think is the basis for this theory?

Name ______________________ Date ____________

Review Chapter 19 Genetics: Mendel's Laws of Heredity

Reviewing Concepts and Vocabulary

1. Mendel chose peas to work with because (circle one letter):

   a. they are easy to grow.
   b. they have a short life cycle.
   c. their reproduction can be controlled.
   d. all of the above.

2. Mendel used ______________ pollination to make ______________ between peas plants that normally ______________-pollinate. Briefly describe the procedure he used:

   ____

   ____

   ____

3. Pure-breeding plants are those whose offspring have the same ______________ as the parent plant.

4. In genetics the offspring of parents, the first generation, are referred to as the ______________ ______________, or F_1 generation. The offspring of the F_1 generation are called the ______________ generation.

5. ______________ are organisms that result from crosses between parents having different expressions of the same trait.

6. Inherited traits are controlled by pieces of DNA called ______________.

7. Diploid organisms have how many of each type of chromosome? How many of each type of gene?

   ____

8. An organism is ______________ for a trait if both genes for that trait are alike. An organism is ______________ for a trait if the genes are different.

9. Mendel crossed round-seed pea plants with wrinkled-seed pea plants; all the offspring had round seeds. Which gene was dominant? Which recessive?

____

10. Paired genes ____________ during meiosis, so that each gamete possesses ____________ gene for each trait. Genes ____________ at random during fertilization. Which of Mendel's laws of heredity does this describe?

____

11. Mendel's law of independent assortment states that a gene goes into a sperm or egg independently of other genes. Is this strictly true? Explain.

____

____

12. During meiosis what event could separate two genes that are on the same chromosome?

____

13. Breeders obtain consistency in a strain of animals by the technique of ____________; it results in an increase in the number of individuals in the stock that are ____________ for desired traits. When breeders want to combine traits from two different strains they use the technique of ____________. These are both cases of ____________ selection.

Applying Concepts

14. If two genes are on the same chromosome, is the likelihood that they will be passed on to the next generation as a pair greater or less than if they were on different chromosomes? Explain your answer.

____

____

15. In corn, the gene for yellow seeds is dominant over the gene for white seeds. A plant with yellow seeds was pollinated by corn pollen from an unknown source. Out of the first four ears of corn produced three had yellow seeds, and one had white. What can you conclude about the parent plants?

____

____

Name ______________________________ Date ____________

16. Consider a case in which a pair of identical twins were separated at birth. One twin grew up in a poor area and had a meager, low-protein diet. The other twin had a more generous, protein-rich diet. At the age of 18, when the twins were reunited, the twin who had the better diet was larger and taller than the other.

    a. Were their genotypes the same or different?

    ____

    b. Were their phenotypes the same or different?

    ____

    c. How did the differences between them arise?

    ____

17. An experiment was conducted using two pure-breeding strains of mice, one black (BB) and one white (bb).

    a. When these two strains were crossed, what were the genotypes of the offspring? What were their phenotypes?

    ____

    b. Pairs of mice from the F_1 generation are then crossed. Draw a Punnett square to predict the offspring from this cross:

    c. What is the probable ratio of the genotypes? of the phenotypes?

    ____

18. In cattle, hornless (or polled, P) is dominant over horned (p). A hornless bull is bred with three cows. A mating with cow 1, horned, produces a horned calf; with cow 2, polled, produces a horned calf; and with cow 3, polled, produces a polled calf. What are the genotypes of:

the bull? ______________

cow 1? ______________

calf 1? ______________

cow 2? ______________

calf 2? ______________

cow 3? ______________

calf 3? ______________

Name ______________________________ Date ____________

Review Chapter 20 **Heredity: Chromosomes and Genes**

Reviewing Concepts and Vocabulary

1. Human cells each contain 46 ________________. In females 23 pairs are ________________. In males 22 pairs are ________________; the remaining pair is composed of one ________________ and one ________________ chromosome.

2. The gene for white eyes is sex-linked in *Drosophila*. On which chromosome is it located?

   ____

3. The failure of chromosomes to separate during meiosis is known as ________________.

4. A ________________ mutation involves addition, loss, or rearrangement of a section of chromosome. A ________________ mutation results in the alteration of the base sequence in DNA within one gene.

5. Down's syndrome is an example of a ________________ mutation; sickle-cell anemia is an example of a ________________ mutation.

6. Most mutations are (circle one letter):
   a. advantageous.
   b. recessive.
   c. lethal.
   d. generated by the organism to increase variability.

7. Substances that cause mutations are known as ________________.

   Give two examples:

   ____

   ____

8. Cells that have more than two sets of chromosomes are ________________.

   This is another example of a ________________.

9. Alternate versions of a gene for a trait are called ______________. Their position on homologous chromosomes is referred to as the ______________.

10. Thomas Hunt Morgan's studies of linkage and crossing-over in ______________ ______________ showed locations of genes on a chromosome, enabling a ______________ ______________ to be constructed. In applying results of crossing-over experiments, Morgan reasoned that crossing-over has a ______________ chance of occurring the farther apart genes are on a chromosome.

11. Calvin Bridges, one of Morgan's students, noted exceptions in sex-linked inheritance in fruit flies, a genetic event due to ______________, a failure of chromosomes to ______________ during meiosis.

12. In 1928, ______________, an English bacteriologist, worked with two strains of pneumonia and discovered that the bacteria contained a "transforming" substance that acted like a ______________. Avery, McCarty, and MacLeod later proved that this chemical substance is ______________.

13. Twelve years before Watson and Crick developed their model of DNA, ______________ and ______________ hypothesized about how genes work; it is called the one ______________-one______________ hypothesis. Briefly stated, what does this hypothesis suggest?

____

14. Most characteristics of plants and animals cannot easily be sorted into definite categories, such as curly hair or straight hair, but show variation in many gradations. How is this genetically controlled? What other factor is involved?

____

____

____

____

____

Applying Concepts

15. After a name tag was lost in a maternity ward a nurse was not sure which baby belonged to which mother. She performed blood tests to find out. Mother 1 was type A, and Mother 2 was AB. Baby X was Type A, and Baby Y was O.

    Which baby belonged to Mother 1? ____________.

    Which baby belonged to Mother 2? ____________.

16. At birth, Rh+ babies born to Rh− mothers are often suffering from respiratory failure and require immediate blood transfusions. Why?

17. What relationship between genes and enzymes is evident in studying the disorder phenylketonuria (PKU)? How does this involve the genetic code?

18. An example of the application of modern DNA research is the transplanting of a gene for making insulin from a rat cell into the DNA of a bacterium. What is the name for this technology? Why are bacteria chosen for this process?

19. Red eyes are dominant over white eyes in the fruit fly. If 10 percent of the males in a lab population of *Drosophila* have white eyes, a sex-linked trait, what is the probability that a female in this population will carry a gene for white eyes? Explain.

Name ______________________ Date ____________

Review Chapter 21 **Change Over Time**

Reviewing Concepts and Vocabulary

1. The theory of ______________ states that living organisms are able to develop from nonliving things under certain conditions.

2. Aristotle believed that the difference between living and nonliving things is the presence of an ______________ ______________ in living things.

3. In Redi's experiments with flies and meat, why was the sealed jar not considered an adequate control? What control did Redi use instead? Why?

4. In Pasteur's experiment, what happened when he tipped the broth into the swan-neck flask? How did this procedure affect the results of the experiment? What theory was disproved by this experiment?

5. According to Oparin's hypothesis, which arose first on earth, photosynthesizing organisms or non-photosynthesizing organisms? What is the name given to this hypothesis?

6. Gaseous oxygen was not present in the primitive earth's atmosphere. What did Oparin hypothesize as to the source of oxygen in the atmosphere?

Name ______________________________ Date ____________

7. How did the ozone layer form? What function does it serve for organisms on earth?

____

____

8. a. In Miller and Urey's experiment, what gaseous substances were used as the starting point? Were these present in the earth's atmosphere before life developed?

____

b. What energy source did Miller and Urey use to cause the gases to react? What products were formed?

____

____

9. Parts or traces of organisms that are preserved over time are called

______________.

10. Carbon-dating and potassium-argon dating are dating methods that are based on the fact that ______________ substances change to ______________ substances.

11. What clues do fossils, homologous structures, similarities in embryo development, vestigial organs, and similarities in chemical composition provide about living organisms?

____

____

12. The changing of species over time is referred to as ______________.

13. Lamarck proposed a theory to explain how organisms may inherit acquired characteristics based on his observations of ______________ and

______________.

14. What theory did Darwin and Wallace propose to explain how species change over time? What are the three basic statements of this theory?

____

____

____

____

Applying Concepts

15. The hypothesis proposed by Oparin to explain the beginning of life on earth seems reasonable to most scientists. However, it is still incomplete. What part of the story is missing (circle one letter)?
    a. The development of simple organic molecules.
    b. The development of complex organic molecules.
    c. The development of cells.
    d. The development of animals and plants from cells.

16. Suppose you have two pieces of rock, one dating to the Carboniferous period of the Paleozoic era, the other dated in the Jurassic period of the Mesozoic era. In which rock would you expect to find fossilized ferns? In which would you find dinosaur fossils? How could each of these fossils have formed?

____

____

____

____

____

17. What do you suppose might have happened to the peppered moth population in industrial England if they had not carried an allele for dark coloration? Explain. What if this had been the only population of this species of moth in existence?

____

____

____

18. In Europe there are two species of crows, the hooded crow and the carrion crow. At present, their ranges overlap. They are believed to have evolved from a single species.

    a. Did their ranges always overlap? Explain.

____

____

    b. The crows are thought to have separated into two species during the Ice Age, when much of Europe was covered by glaciers. Why is this the most likely time for their speciation?

____

____

Name ______________________________ Date ______________

Review Chapter 22 **Interactions in the Ecosystem**

Reviewing Concepts and Vocabulary

1. In the table below, write the names of each of the following types of organisms in the column corresponding to their method of obtaining food: slime molds, algae, paramecia, rabbits, oak trees, bacteria, human beings.

Producers	Consumers	Decomposers

2. The consumers that eat herbivores are categorized as ______________ consumers in a food ______________.

3. A feeding network made up of food chains is termed a ______________ ______________.

4. An energy pyramid diagrams the flow of energy from one type of organism to another. Which type of organism is not included in energy pyramids? What form of energy is represented in an energy pyramid? What form of energy is lost at all levels?

____

____

____

5. Precipitation, evaporation, and ______________ are processes involved in the cycling of ______________ in an ecosystem.

6. In what form does carbon return to the environment when fossil fuels are burned? How is this form of carbon then reintroduced into living organisms?

____

____

7. Nitrogen ________________ is a process in which ________________ convert nitrogen gas to nitrates. The process whereby ________________ change ammonia to nitrates is called ________________. Ammonia is produced when decomposers break down ________________ in dead organisms.

8. A ________________ relationship is any that involves close interaction between organisms of different species. Interaction between members of the same or different species who are rivals for a limited resource is termed ________________.

9. Match each name of a relationship between organisms with its correct description:

Predation	The organisms are rivals for resources.
Mutualism	One organism derives benefit, the other is unaffected.
Commensalism	One organism derives benefit at the other's expense.
Parasitism	One organism preys on another.
Competition	Both organisms gain some advantage from the interaction.

Applying Concepts

10. a. Draw two energy pyramids, one, pyramid A, depicting the passage of energy directly from plants to human beings, the other, pyramid B, depicting the passage of energy from plants to cattle to human beings.

b. Assuming that the amount of production by the plants is the same, which pyramid will support the larger human population, A or B (circle one)?

11. Before the advent of chemical fertilizers, farmers used to change the crops they grew in any field from year to year. In particular, every few years they would grow a crop of alfalfa, clover, or beans in each field. Why did they do this?

____

____

Name ____________________ Date __________

12. a. Draw a food chain to represent feeding relationships in a community consisting of: corn, mice, and foxes.

b. One of the most important jobs that ecologists have to do is predicting the effects of disturbances on ecosystems. What will happen to the mice in this food chain if a farmer decides to eradicate the fox population?

____

____

c. Following this, what will the effect be on the corn?

____

13. Construct a food web for a community that includes the organisms in the preceding question, and add: cattle, hawks, human beings, and decomposers.

14. Classify each of the following symbiotic relationships into one of the five types:

a. Clown fish are immune to the stinging cells of sea anemones. They live very close to the anemones, darting in among the tentacles when danger threatens.

____

b. Cattle have complex stomachs which support populations of protists and algae that can synthesize cellulase, an enzyme cattle cannot produce.

____

c. Foxes feed on mice and rabbits; in doing so they remove the less healthy animals from the mice and rabbit populations and keep their numbers in check.

____

d. Ticks live by sucking the blood of mammals.

____

Name ______________________________ Date ______________

Review Chapter 23 **Populations in Ecosystems**

Reviewing Concepts and Vocabulary

1. A population consists of all the ______________ of a certain ______________ found in an area.

2. Rapid, uncontrolled population growth is referred to as a population ______________. The term population ______________ describes the opposite growth pattern. If both of these growth patterns occurred successively in a population, what sort of curve would the graphed population growth show?

____

3. Shortage of food, crowding, natural disasters, and parasitism are all examples of:

____

4. What are the three stages of population growth that are described by an S-shaped curve?

____

____

____

5. In a balanced ecosystem, the population size rises and falls with respect to the ______________ ______________ of that esosystem.

6. The tendency of a biological system to remain in balance is termed *dynamic equilibrium*. Explain what each of these words means with regard to a population in an ecosystem:

____

____

____

____

7. Population ______________ compares the number of organisms in a population with the size of the area in which they live.

8. What four rates are used to measure changes in a population over time?

____

9. When environmental conditions are harsh and the population density is high, the ______________ rate and ______________ rate will increase. At the same time, the ______________ rate and ______________ rate will most likely decrease.

10. According to a United Nations projection of human population growth, it may exceed ______________ billion by the year 2000.

a. What is the major factor in this increase?

____

b. What technological advances have contributed to this factor?

____

c. What do many scientists see as the principal limiting factor in human population growth? How is this related to carrying capacity?

____

Applying Concepts

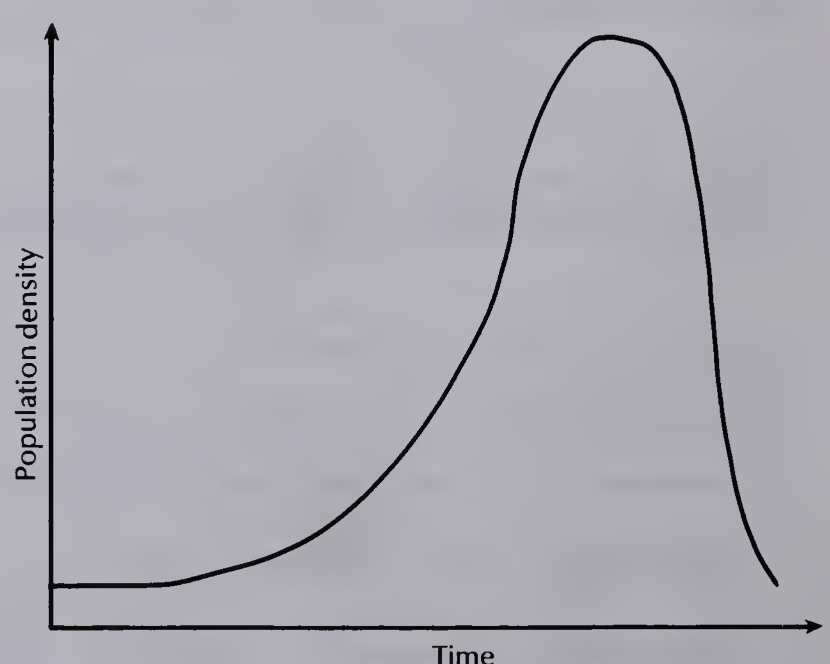
11. An experiment was performed using a population of yeast placed in a jar containing a solution of nutrients, and with a plentiful supply of oxygen. The population changed over time as shown:

a. Yeast tend not to produce much ammonia as a waste product, reincorporating ammonia into proteins instead. Considering that, why did the population growth decrease?

____

b. What type of curve is represented in this graph? What term is used to describe this change in population growth?

____



Name ______________________________ Date ____________

12. In an experiment, a population of unicellular algae was grown in a tank containing a solution of inorganic nutrients which was exposed to light. Some daphnias were then added to the tank of algae. Daphnias feed on algae. The populations of algae and daphnias were monitored and graphed, with these results:

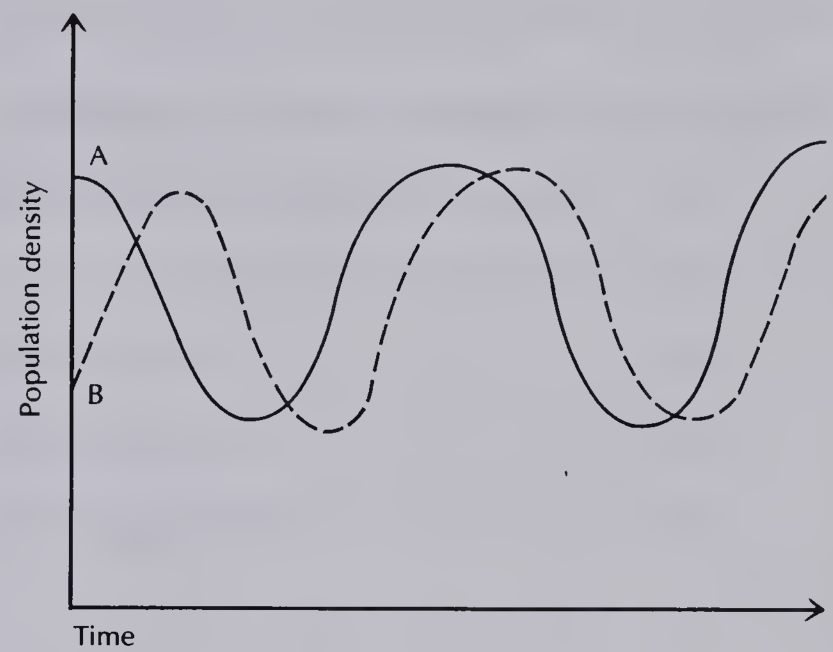
a. If the population of daphnias increases, would you expect the population of the algae to increase, decrease, or stay the same?

____

____

b. If the algae population increases, would you expect the daphnia population to increase, decrease, or stay the same?

____



c. On the graph, which curve represents which species?

Curve A ______________ Curve B ______________

13. Consider a population of the butterfly *Euphydrias* living in the hills of California. These butterflies have been extensively studied by biologists at Stanford University who want to determine ways in which populations can change. The population density of this butterfly population changed over the course of several years as shown in the graph:

a. In 1976 the population died out altogether. How might it start up again?

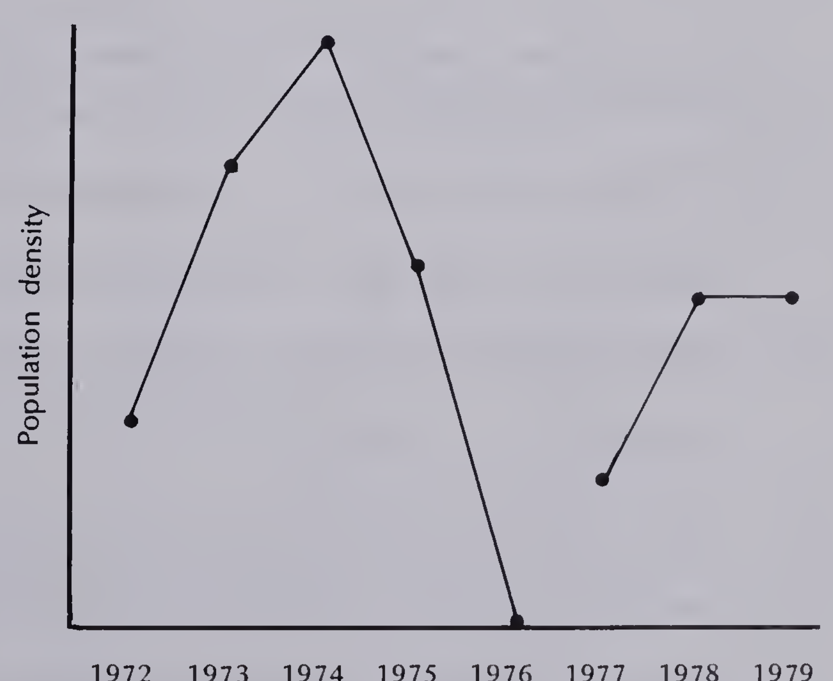
____

b. In 1977 the population was very small. At that time, which do you think was higher, the immigration rate or the emigration rate?

____

c. Which of these rates do you think was higher in 1976?

____



d. In which year was the sum of the birth rate and the immigration rate equal to the sum of the death rate and the emigration rate?

____

Name ______________________________ Date ______________

Review Chapter 24 The Geography of Ecosystems

Reviewing Concepts and Vocabulary

1. In the process of dispersal, plants and animals move away from their

   ____________________ habitats.

2. Dandelions produce many small tufted seeds; these are dispersed by

   ____________________. A coconut fruit is adapted for dispersal by

   ____________________. By what other means do animals disperse? plants?

   ____

   ____

   ____

   ____

3. The mammals of Australia are mostly marsupials. They are different from mammals found elsewhere in the world because (circle one letter):

   a. The biomes in Australia are different from those in the rest of the world.
   b. Australia is surrounded by oceans, which act as a barrier to dispersal.
   c. The mammals in Australia have evolved more slowly than mammals elsewhere.

4. A ____________________ is the place where an organism lives; the particular role played by an organism as it interacts with living and nonliving things in the environment is referred to as its ____________________. What factor can cause both of these to change for an organism?

   ____

5. The earliest plants to settle in an area are called ____________________. The last residents to live in an area are members of a ____________________ community.

6. The process of change in an area, from colonization to the final community, is called

   ____________________ ____________________.

7. A newly formed lake usually starts out with very few plants or animals. How do they reach this body of water? Give two examples:

____

8. Soil that accumulates on the edges and bottom of a lake comes from what two sources?

____

9. The two terrestrial biomes having the lowest species diversity are

_______________ and _______________. The highest species diversity is

found in the _______________ biome.

10. The soil in the _______________ biome is low in nutrients because dead organisms are rapidly broken down and their nutrients quickly absorbed by plants.

11. Few trees grow in grasslands because there is too little _______________. Name two types of herbivore found in this biome and their predators:

____

12. In the tundra, the growing season may only last about _______________. In winter, the tundra is not only cold but also _______________. The layer below the surface is called _______________ because it is always frozen. Name a climax plant and animal from this biome: _______________

13. Deserts are defined by lack of _______________; most deserts receive less than _______________ cm of _______________ per year. Name a climax plant and an animal from this biome: _______________ _______________

14. In which forest biome would you find wolves and moose? In which forest biome would you find an average rainfall of between 80 cm and 150 cm?

____

15. Which will contain more floating producers, a fast-flowing stream or a slow-moving one? What name is given to these producers?

____

16. In which aquatic ecosystem would you find marshes with salt-tolerant plants?

____

Applying Concepts

17. Which would you expect to have lower water and nutrient requirements: (a) the first species to colonize an area, or (b) those species remaining when the area reaches it final, stable state? Why?

____

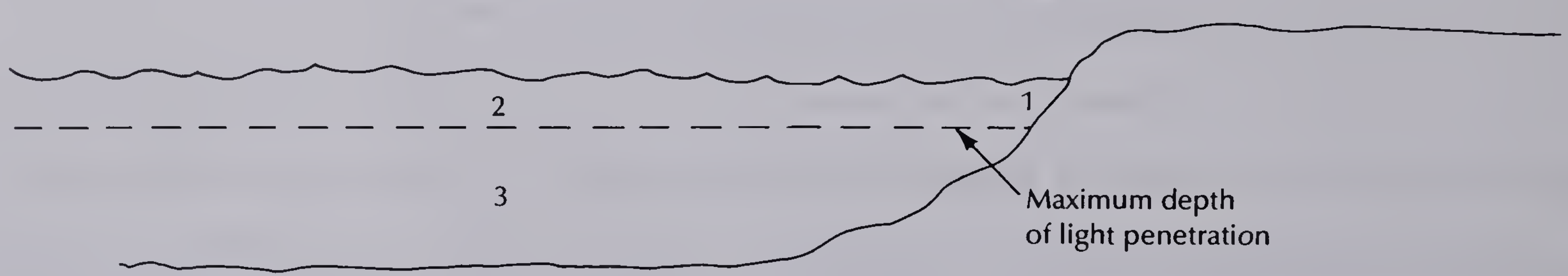
____

18. Tundra is found at the tops of tall mountains. It is also found near the North Pole and South Pole. Describe each of these in terms of plant and animal communities and climate. What terms are used to describe each environment?

____

____

19. The diagram represents the habitat zones available in either a lake or a sea (the two are fairly similar).



a. In which of the pictured zones would you expect to find:

large aquatic plants? ____________

free-floating, small producers? ____________

a community mostly consisting of scavengers or decomposers? ____________

b. In the bottom of the sea or lake there are no producers; why not?

____

c. What do the organisms in the deepest areas use as a food source?

____

d. How are inorganic nutrients moved from their site of release by decomposers to their site of use by producers?

____

____

Name ______________________ Date ____________

Review Chapter 25 **Behavior**

Reviewing Concepts and Vocabulary

1. Indicate how each behavior listed below is acquired, as learned or inherited:

    a. A dog sitting in response to a command: ______________________

    b. Stickleback male courting a female: ______________________

    c. A human jumping at a sudden noise: ______________________

    d. A cat getting excited when it hears a can opener being used: ______________

2. ______________ are growth movements of plants, directed toward or away from an environmental stimulus. When light stimulates this response it is termed ______________.

3. Two forms of behavior found in animals having simple nervous systems are ______________, in which the organism responds by moving randomly, and ______________, in which the response is toward or away from a stimulus. What form of movement is involved in both behaviors?

    ____

4. The ______________ is the simplest behavior of a well-developed nervous system.

5. ______________ are complex stereotyped behaviors that are expressed in the same way in all individuals of a species.

6. A(n) ______________ is a specific environmental stimulus that causes an animal's innate response.

7. ______________ is a change in behavior based upon experience.

8. An animal learns to ignore stimuli that are not important by means of ______________. A ______________ response involves a reflex reaction in response to a new stimulus as a result of learning.

9. ______________ is the storing and retrieval of learned information.

Name ______________________________ Date ____________

10. Most organisms are affected by the ____________ cycle. For instance, ____________ animals such as sparrows and humans are active during the day, while ____________ animals such as cats and earthworms are active at night.

11. An instinctive behavior in which organisms make journeys from one region to another and back is called ____________.

12. A factor that causes an organism to repeat a behavior is called a ____________. This is used in a type of learning called ____________ conditioning.

13. The influence of duration of light on an organism is known as ____________.

14. Will short-day plants flower if a flash of light interrupts their period of darkness: Explain.

____

____

15. Environmental stimuli help set an organism's biological clock, which maintains bodily rhythms, such as sleep and wakefulness, on approximately a 24-hour cycle. This is referred to as a ____________ rhythm.

16. An Austrian zoologist, ____________ ____________, observed a type of learning called ____________ in young geese who followed the first moving thing they saw after hatching.

17. Chemical signals produced by one animal that affect the behavior of another animal of the same species are known as ____________.

18. List the three castes of honey bees. Which of these are capable of reproduction? Which caste performs a waggle dance? What is the purpose of this dance?

a. ____________ b. ____________ c. ____________

____

____

____

Applying Concepts

19. Many animals establish social dominance within their societies by mock or ritual conflict. Why is this behavior more advantageous than real fighting would be?

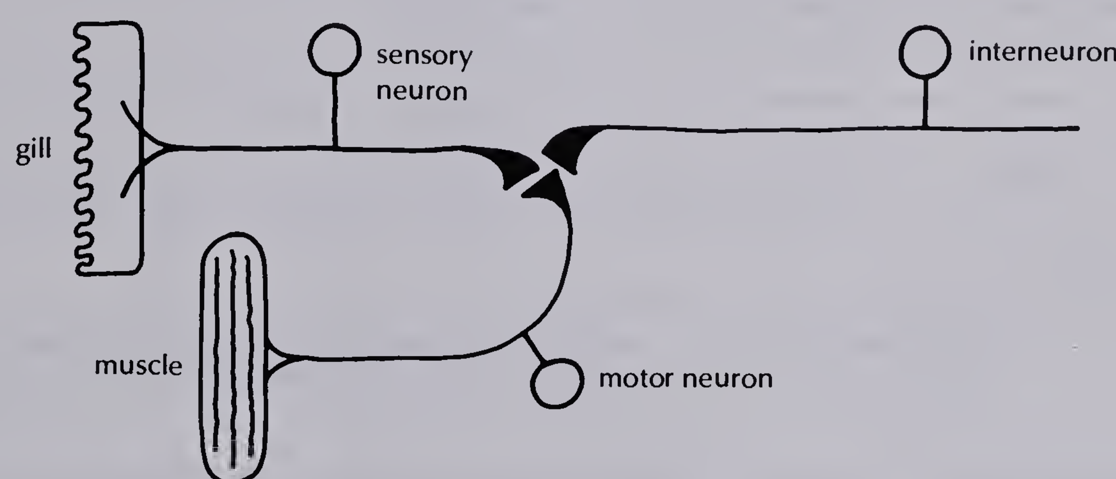
____

____

20. How would you classify the behavior of a blackbird singing to establish a territory: Is this behavior learned or inherited? Is it a reflex or an instinct?

____

21. The neuronal basis for learning has been studied in a very simple animal, a sea slug called *Aphysia*. A sensory neuron is activated when the animal's gill is touched; in turn, that activates a motor neuron which drives a muscle, causing the gill to be withdrawn. (See the illustration below.)



a. It is found that with repeated stimulation of the gill, the efficiency of impulse transmission across the synapses between the sensory and motor neurons decreases. What effect will this have on the animal's behavior?

____

b. What kind of learning is this?

____

c. The interneuron shown is activated when the animal is alarmed, causing an increase in impulse transmission between the sensory and motor neurons. In experiments, electric shock is used to cause the animal to become alarmed. What effect will this have on the animal's behavior? Is this a form of learning? If so, what kind?

____

____

Name ______________________________ Date ______________

Review Chapter 26 **Health and Disease**

Reviewing Concepts and Vocabulary

1. Emphysema, sickle cell anemia, and diabetes are all examples of body

   ______________.

2. The ______________ system is the body's mechanism for chemical defense against ______________.

3. Three examples of environmental factors that can cause disease are:

   ____

4. What are the three main causes of death in smokers?

   ____

5. Alcoholism involves ______________ and ______________ dependence on alcohol.

6. How would you classify barbiturates and amphetamines? What effect does each chemical have?

   ____

   ____

7. Infectious organisms that make their hosts ill are called ______________.

8. An ______________ occurs when there is widespread transmission of an infectious disease and a sizeable proportion of the population suffers from the disease simultaneously. Give an example:

   ____

9. Tuberculosis, cholera, strep throat, gonorrhea, and tooth decay are all caused by

   ______________, a type of disease organism. Give two examples of other types of disease organisms and the diseases they cause:

   ____

   ____

Name ________________________________ Date ____________

Review 26, page 2

10. In what form are bacteria able to withstand boiling, freezing, and drying?

____

11. Many bacteria produce poisons called ______________.

12. The protein coat of a ______________ is adapted to attach to a specific place on a host's cell membrane or cell wall. Name a common disease caused by this type of pathogen:

____

13. Flagellated protozoa known as ______________ cause sleeping sickness. They live in the ______________ of the host. This disease is transmitted by the tsetse fly. How does the tsetse fly pick up the protozoans in the first place?

____

____

14. Malaria is transmitted by the bite of the female *Anopheles* ______________.

15. Parasitic ______________ cause ringworm, dandruff, and athlete's foot. In what form are these disease organisms dispersed and transmitted?

____

16. ______________ are disease-combatting chemicals that are produced by specialized white blood cells called ______________.

17. ______________ is a procedure that involves the introduction of an antigen into a human or animal to induce immunity to a particular disease. What aspect of the normal disease defense mechanisms does this activate?

____

18. Louis Pasteur proposed the ______________ theory which states that microbes cause disease. Pasteur's theory was applied to surgery by ______________ ______________ who encouraged the use of disinfectants in operating rooms.

19. Robert Koch was a German physician who devised a technique to isolate and ______________ the microbe responsible for a disease.

Name ______________________ Date __________

Applying Concepts

20. Can a disease due to a mutation be passed from one adult to another? How are such diseases transmitted?

____

____

21. In technologically advanced societies the incidences of most diseases—particularly infectious and malnutritional diseases—have been greatly reduced. However, the same societies show very high incidences of obesity, hardening of the arteries, heart disease, high blood pressure, and ulcers. What two environmental factors are mainly responsible?

____

22. What specific precautions would you take at home if a member of your family was suffering from an active case of the measles? Explain.

____

____

____

____

23. Suppose you are a doctor treating a patient whose symptoms are weight loss and lack of energy. You discover this person prefers to eat pork that is rare. What parasite would you suspect your patient is harboring? Why?

____

____

____

24. Malaria can be very difficult to treat, and the immune system is very ineffective in treating it. What aspect of the malaria organism's life cycle might account for this?

____

____

____

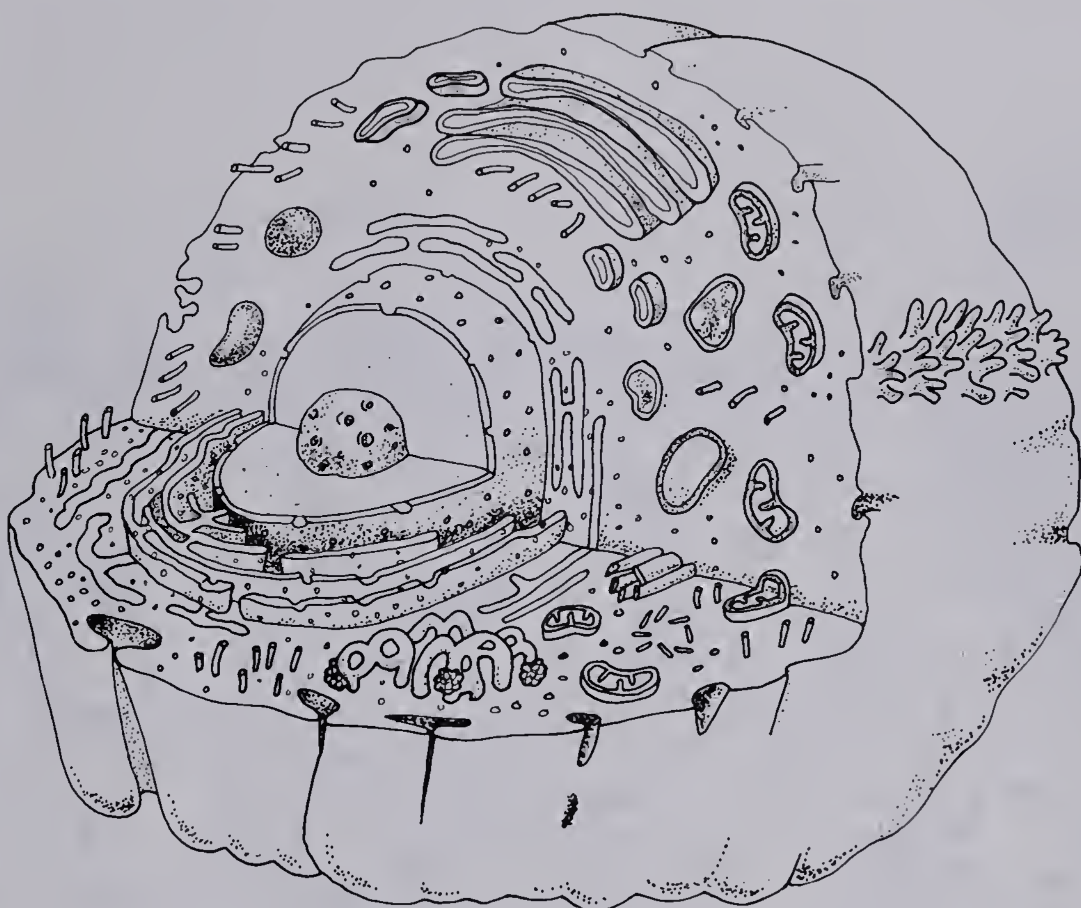
25. One way of checking to see if a person has some hidden infection is to count the number of white blood cells in a blood sample. Would the white blood cell count increase or decrease as a result of infection? Explain.

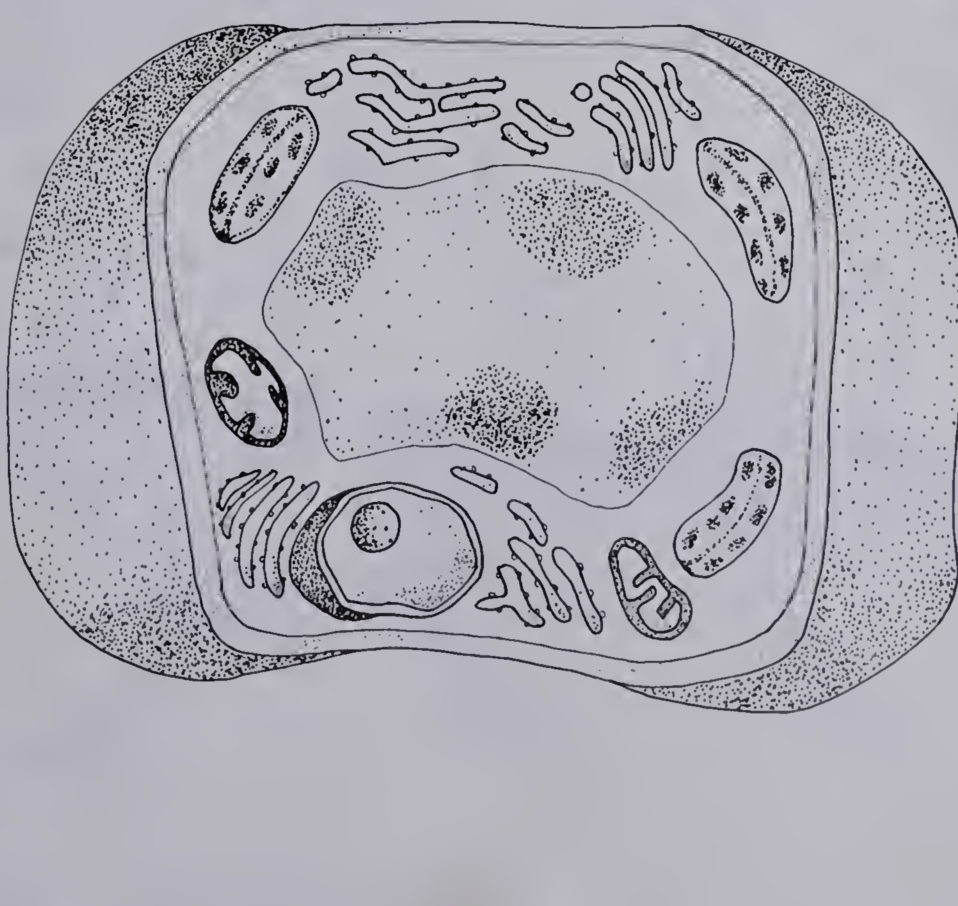
____

____

Name ______________________ Date ____________

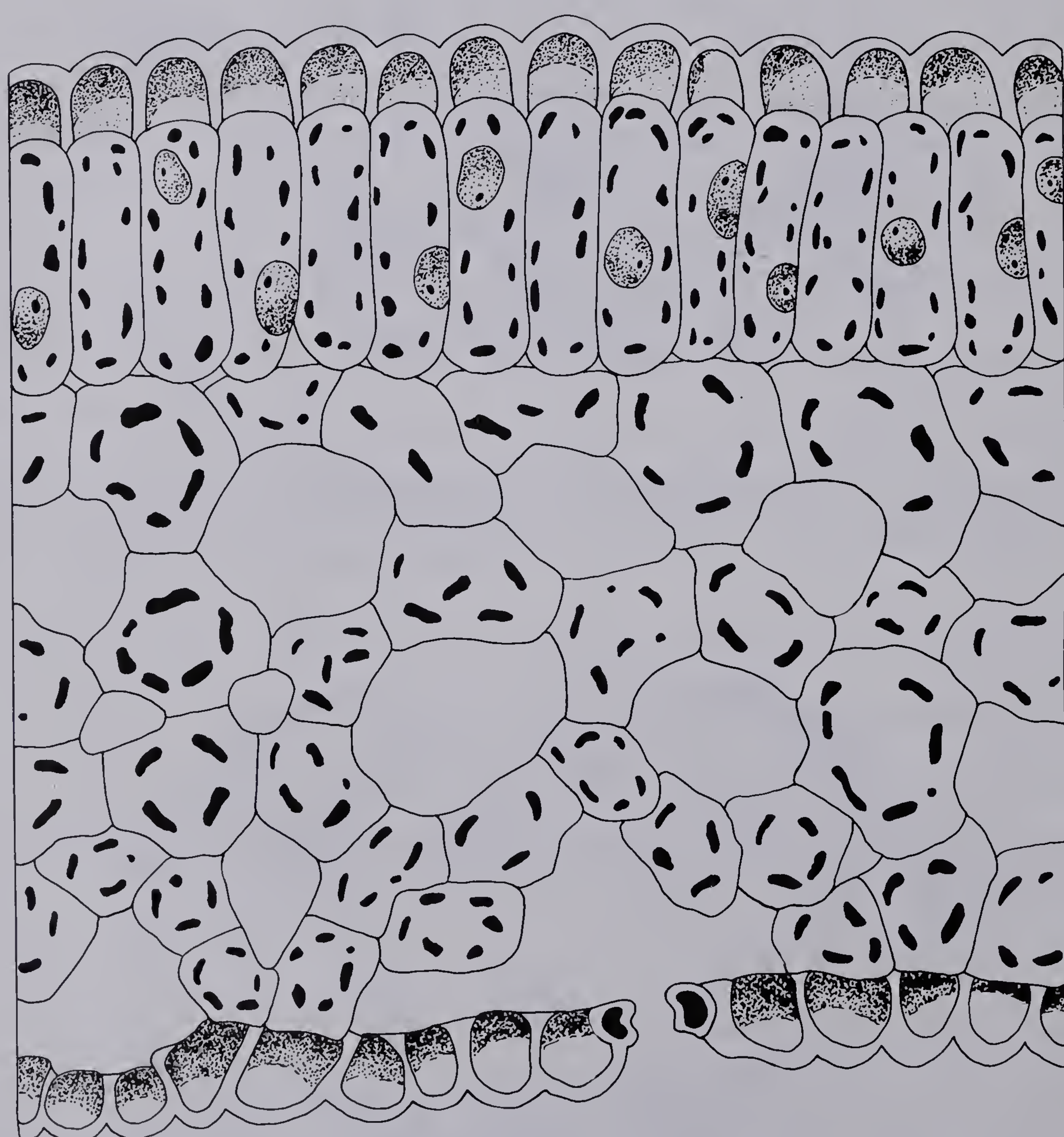
Diagram 1 **Animal and Plant Cells**





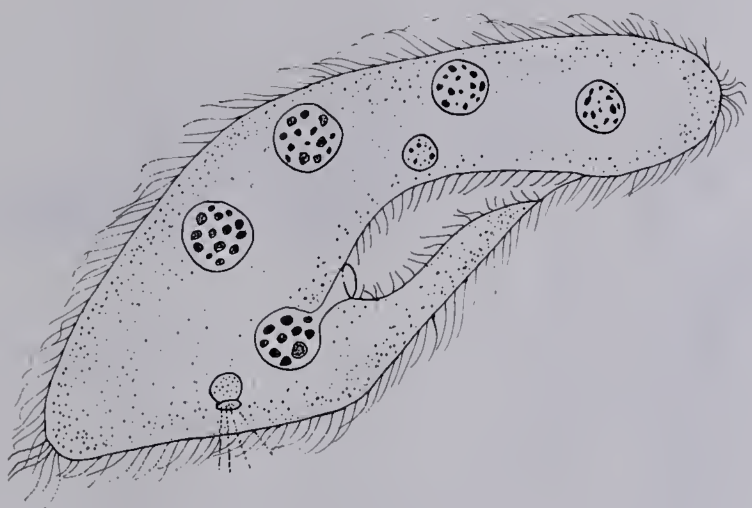
Name ______________________ Date __________

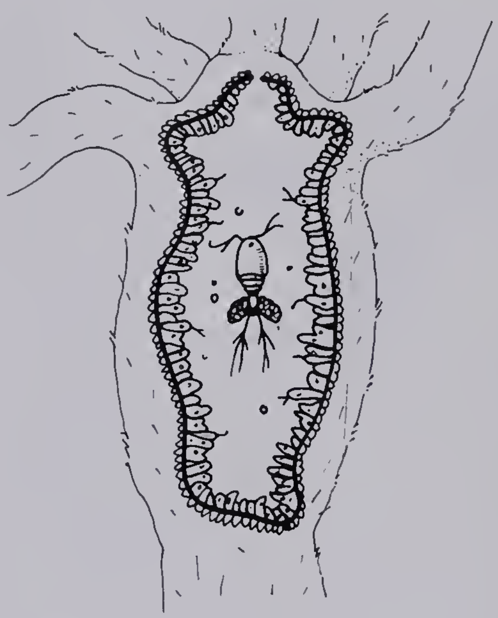
Diagram 2 **Leaf Structure**

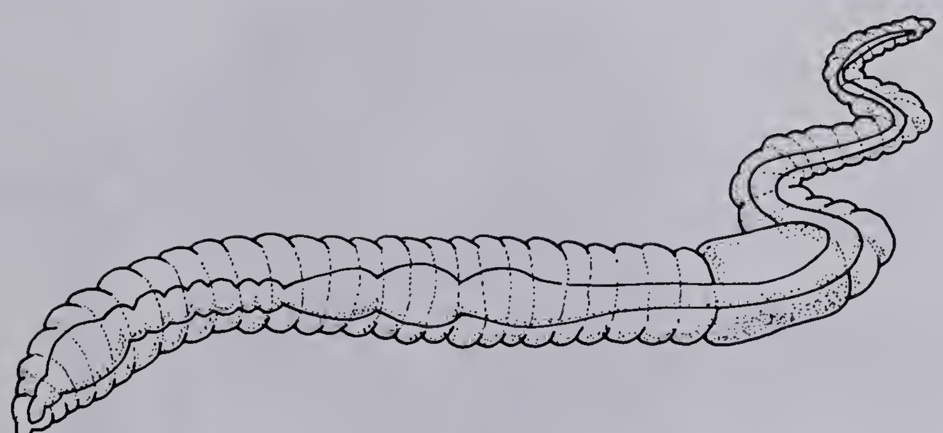


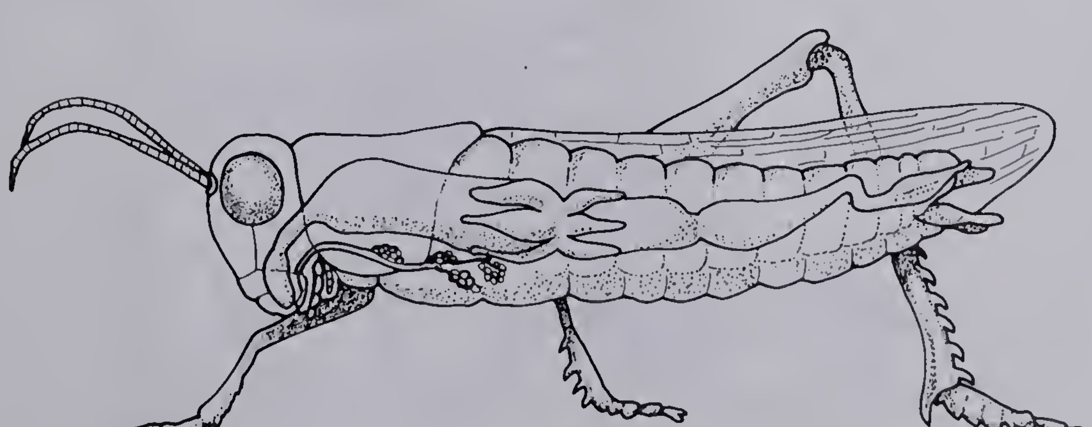
Name ______________________ Date __________

Diagram 5 **Food Processing in the Representative Organisms**



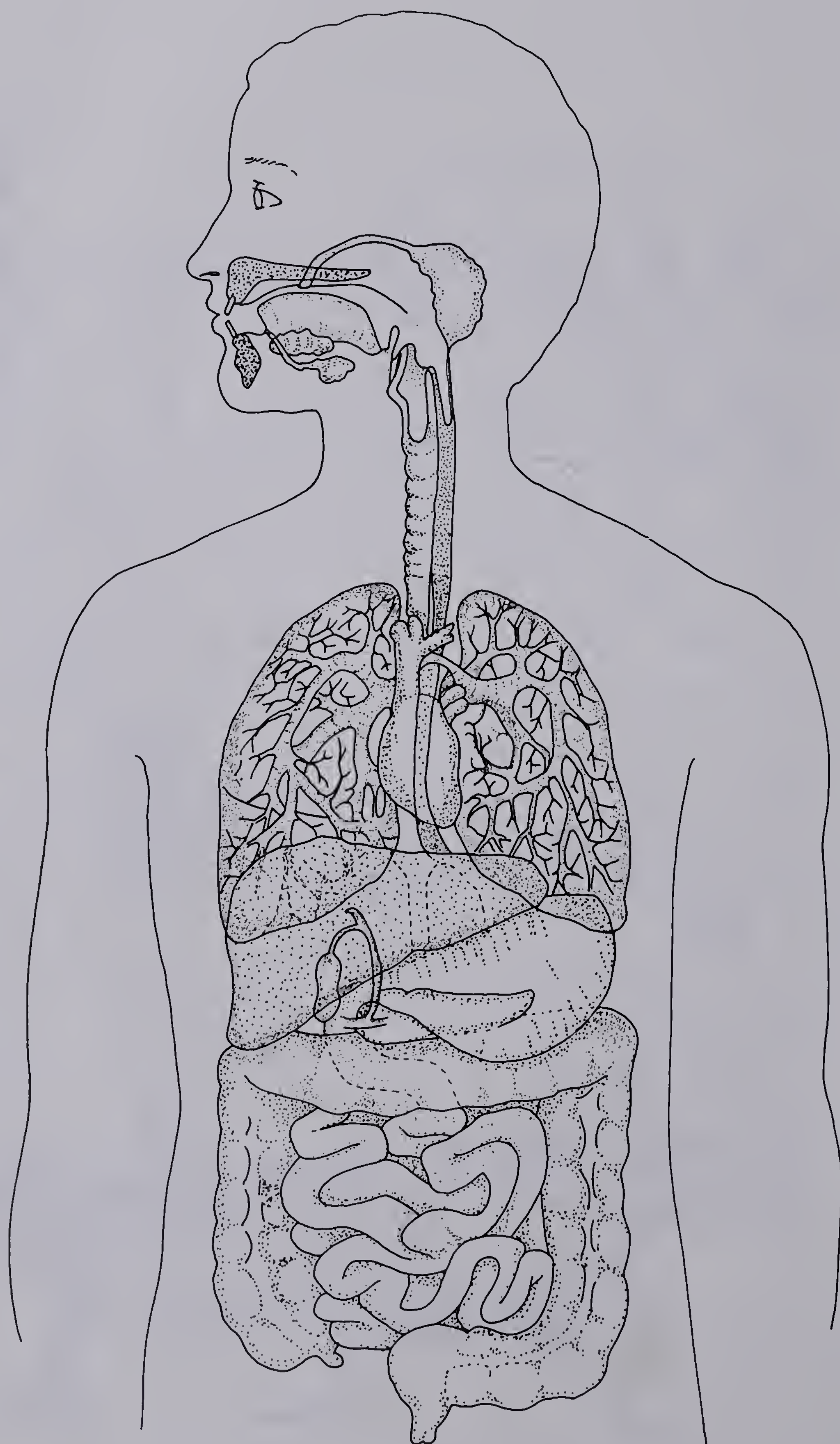






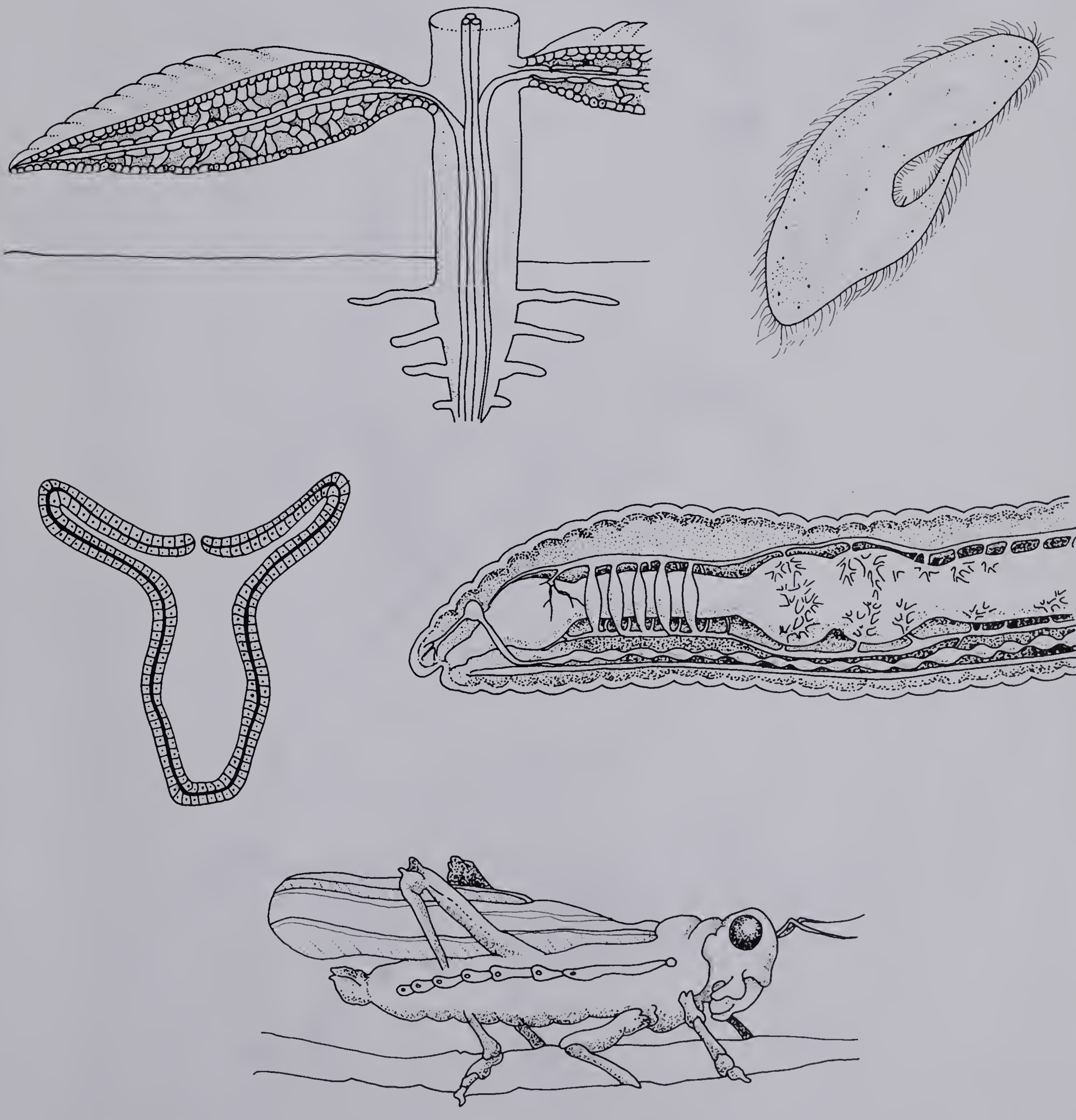
Name ______________________ Date __________

Diagram 6 **The Digestive System**



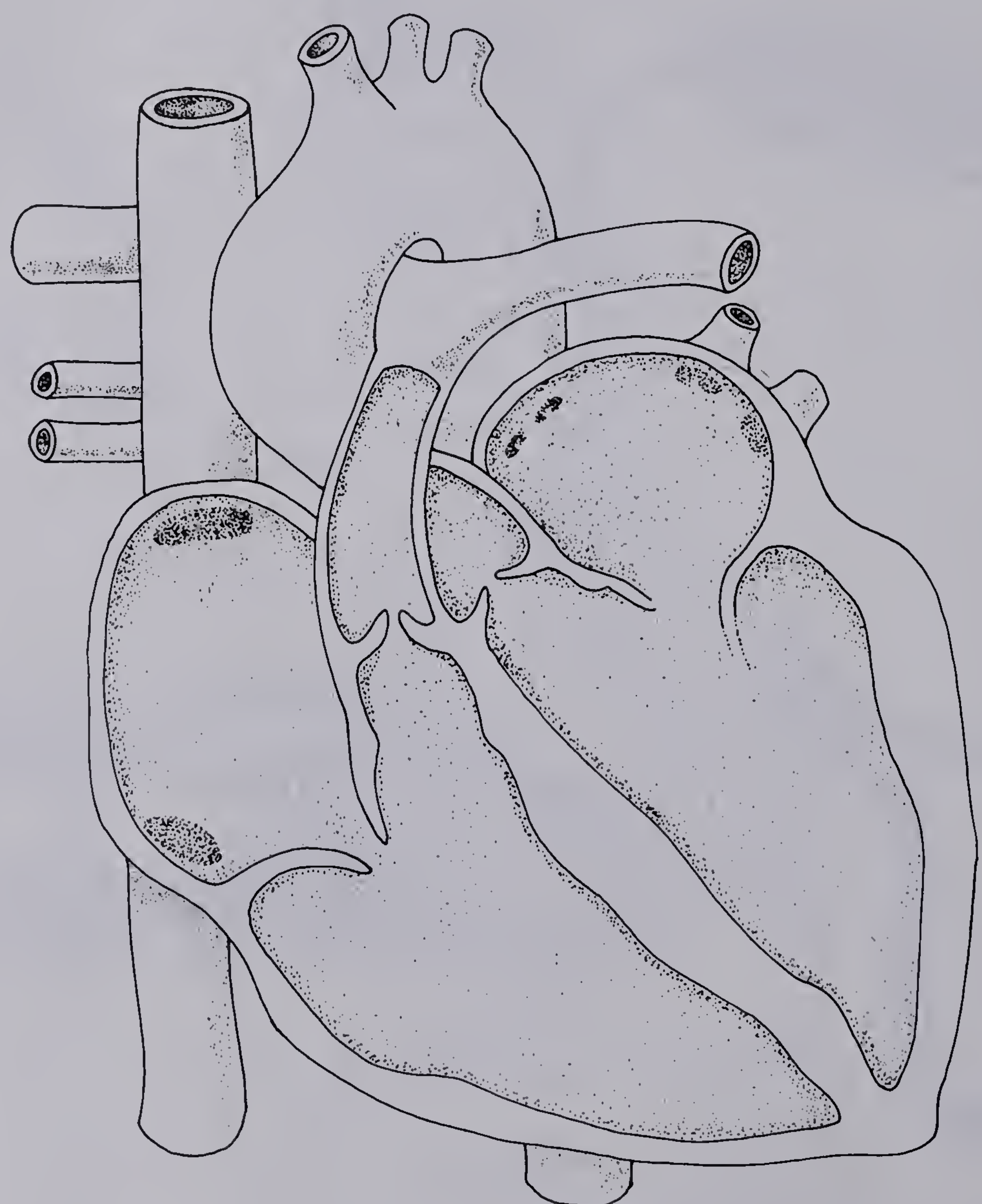
Name ______________________________ Date ____________

Diagram 7 Transport in the Representative Organisms



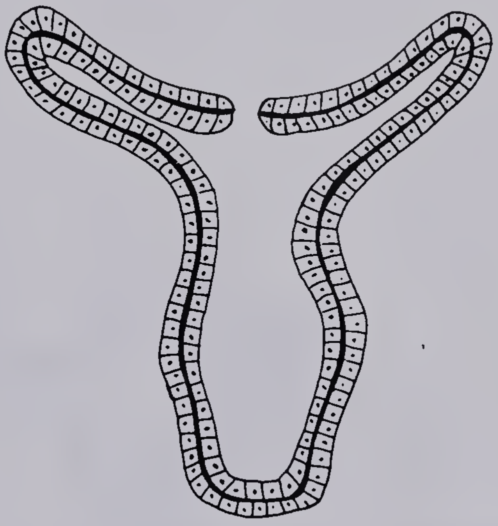
Name ______________________________ Date ______________

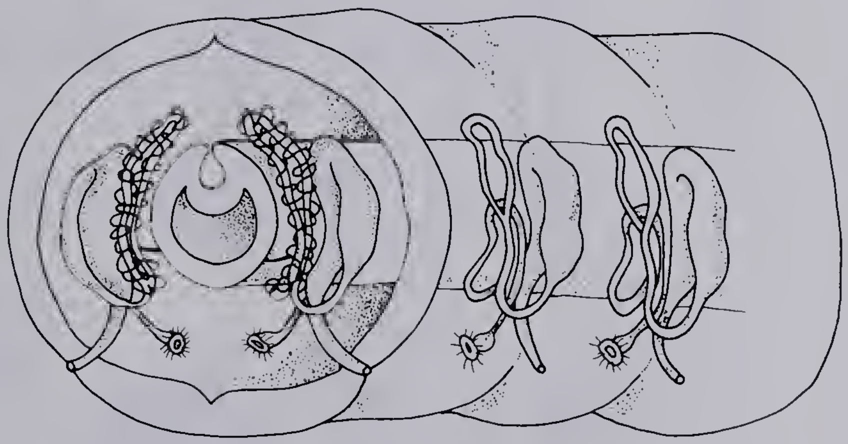
Diagram 8 **The Heart**

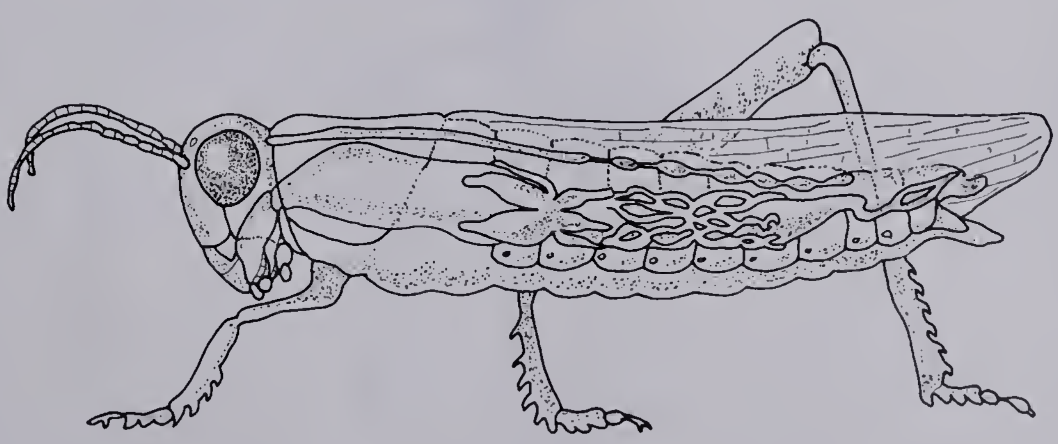


Name ____________________ Date ____________

Diagram 9 **Excretion in the Representative Organisms**

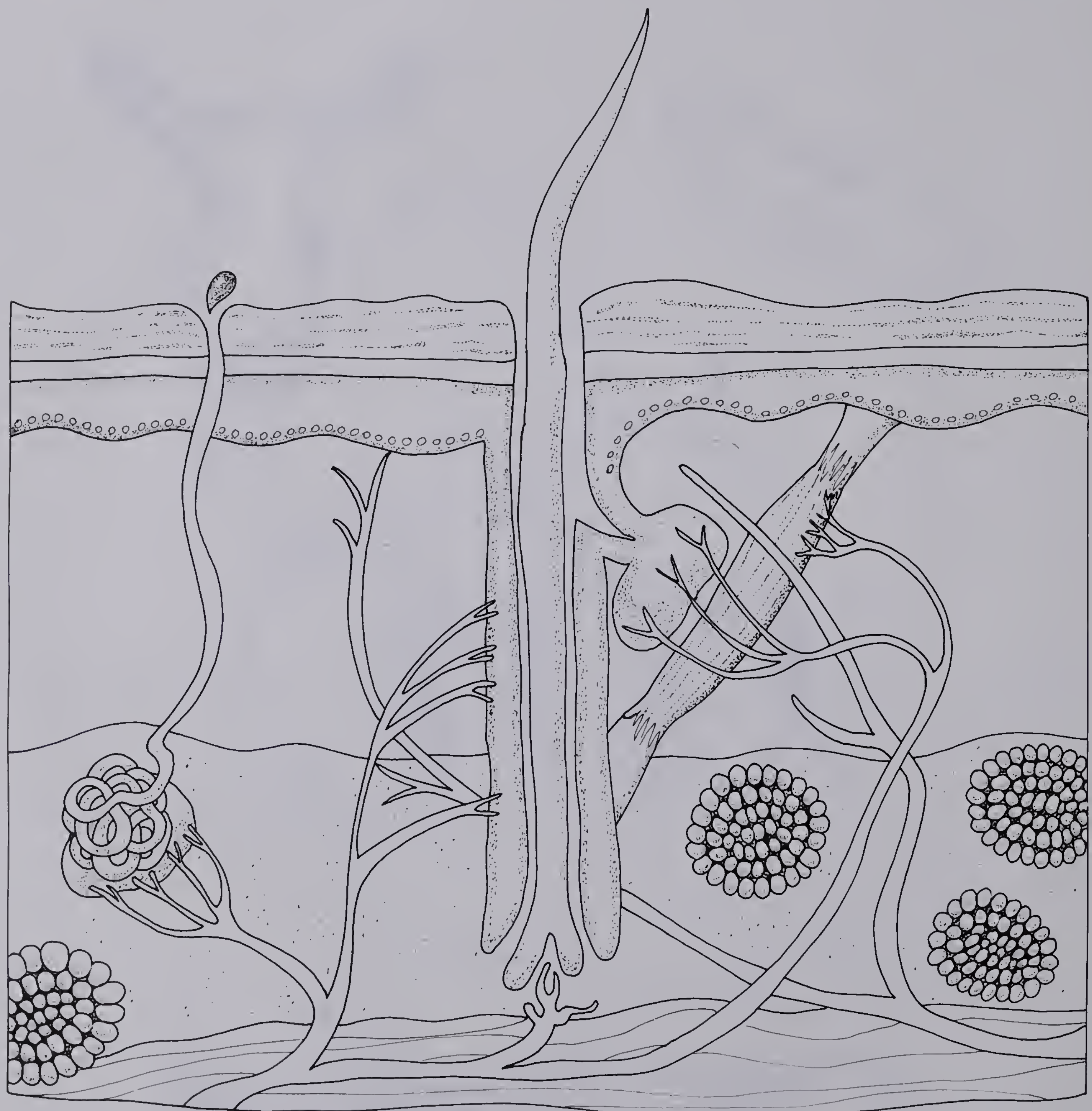






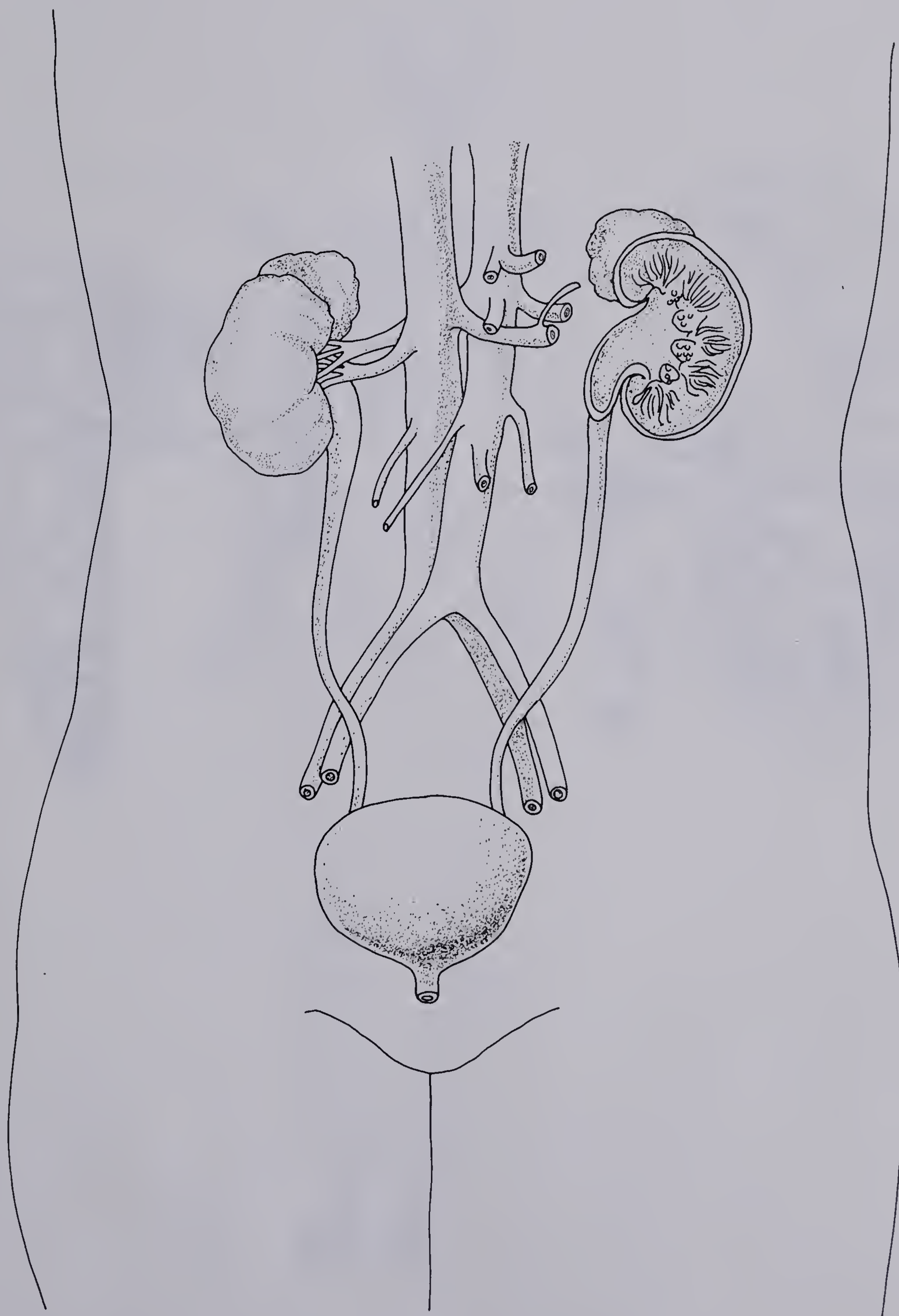
Name ______________________ Date __________

Diagram 10 **The Skin**



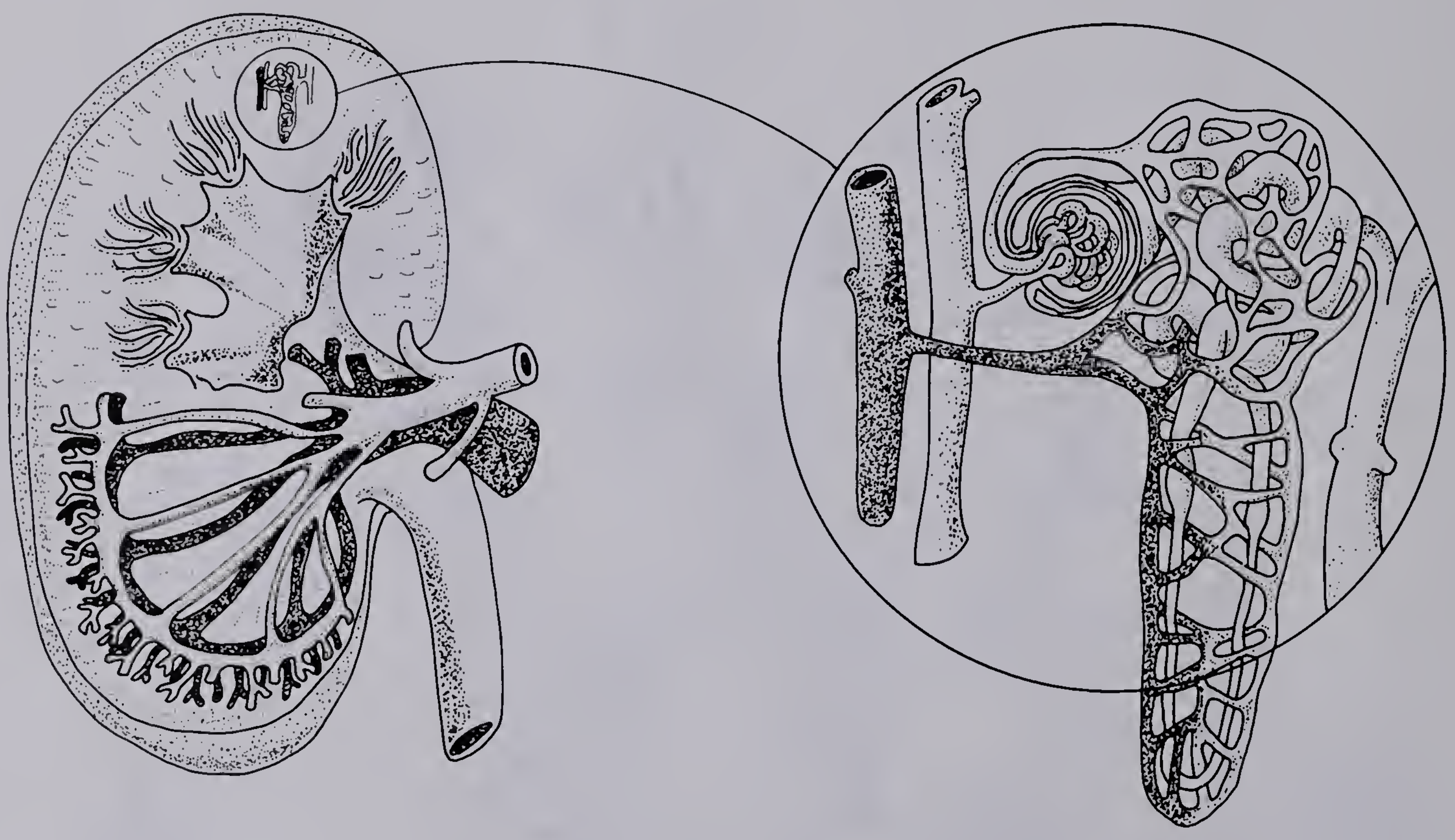
Name ______________________ Date ____________

Diagram 11 **The Urinary System**



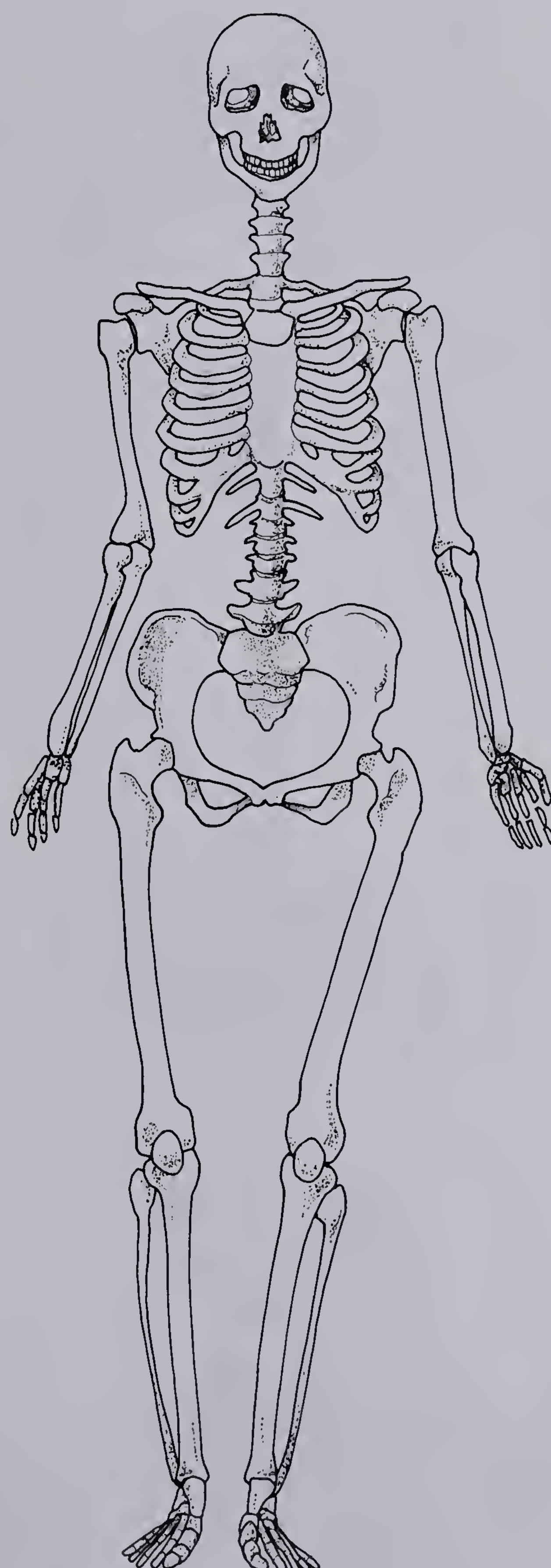
Name ______________________________ Date ____________

Diagram 12 **The Kidney**



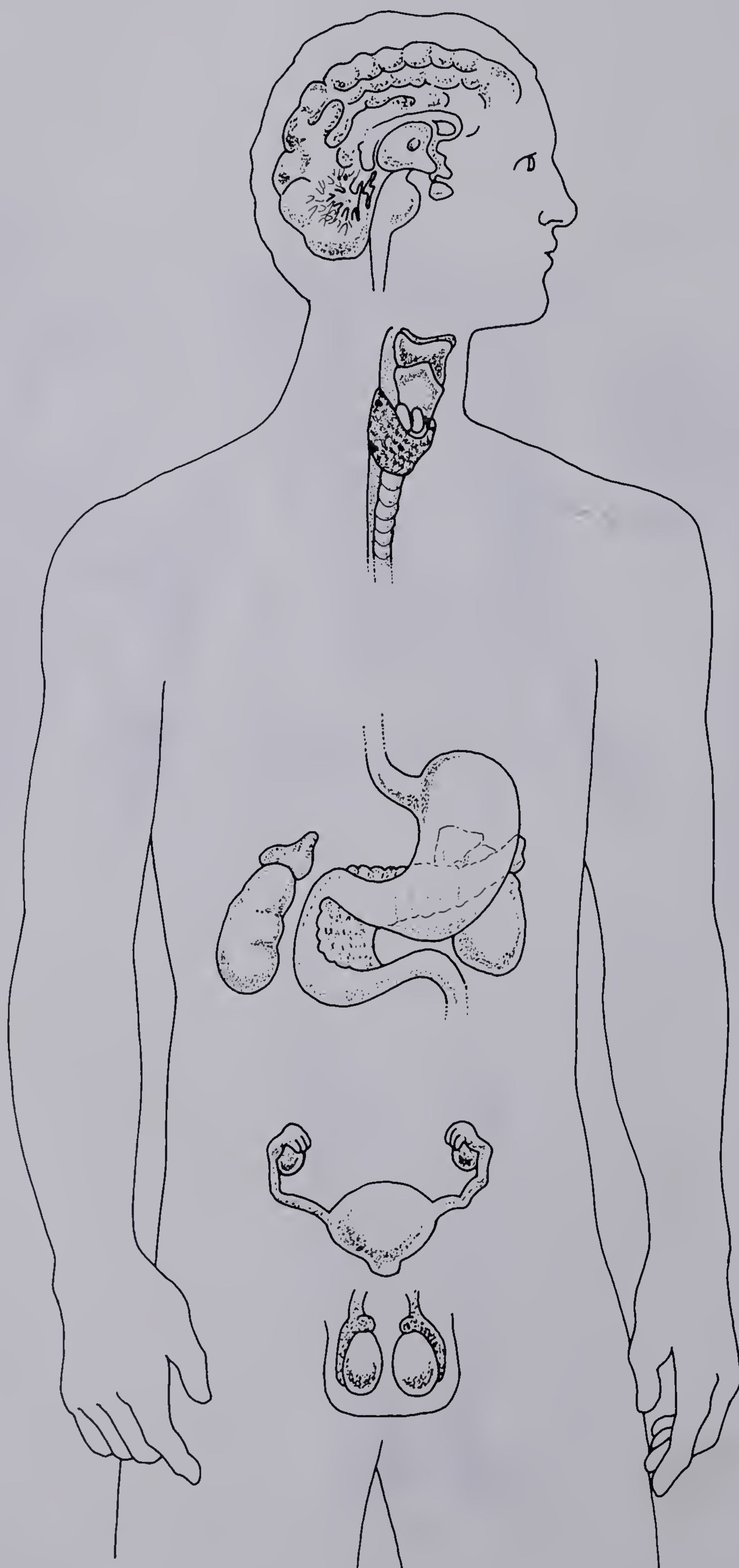
Name ______________________________ Date ______________

Diagram 13 **The Skeleton**



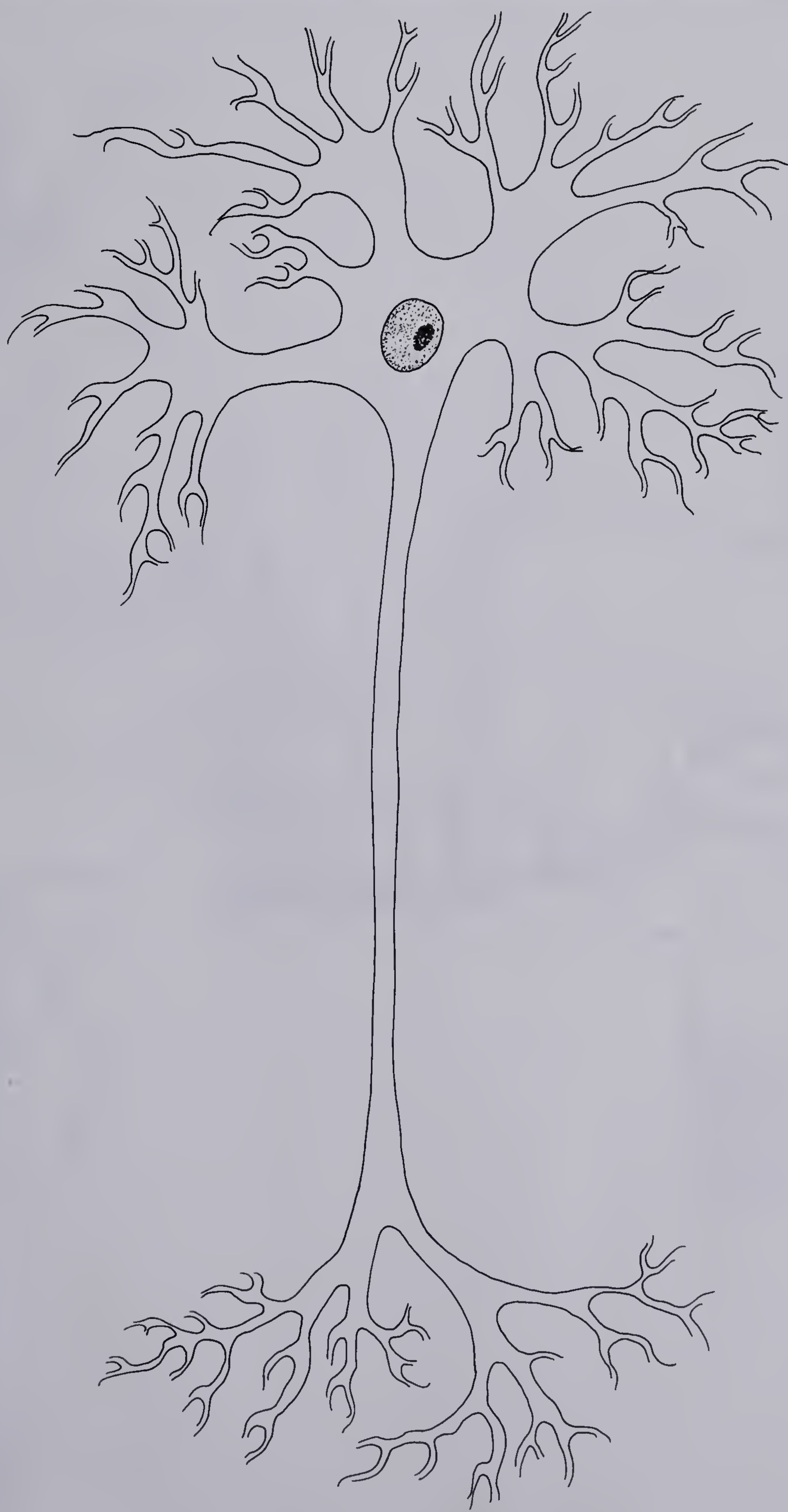
Name ______________________ Date ____________

Diagram 14 **The Endocrine System**



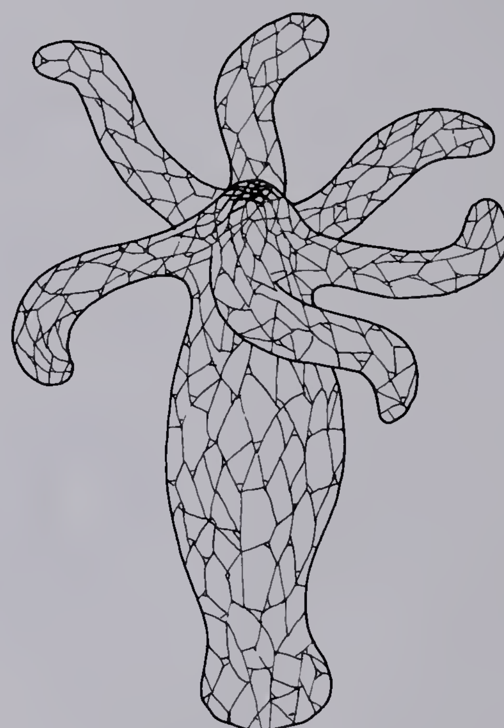
Name ______________________________ Date ______________

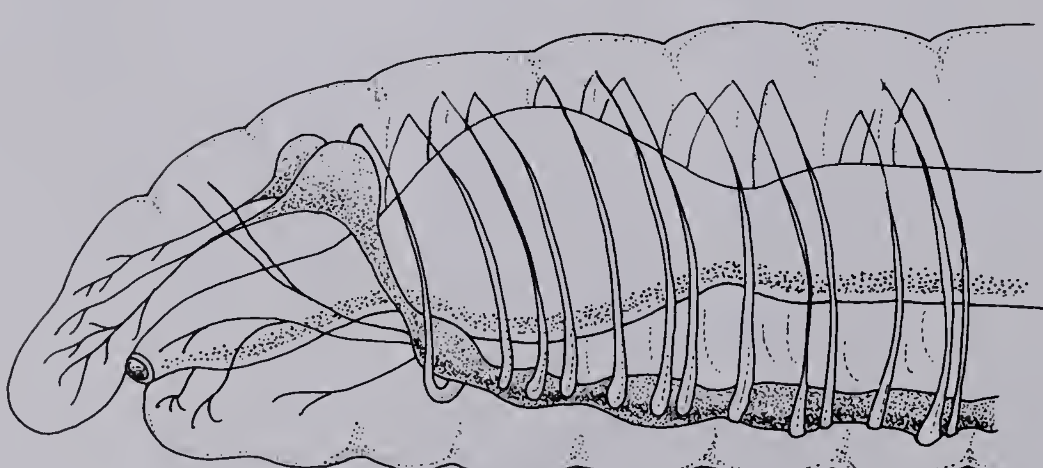
Diagram 15 **Neuron Structure**

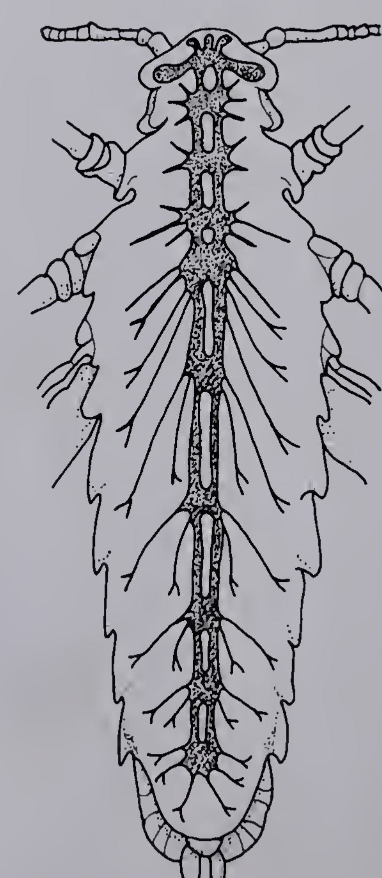


Name ______________________________ Date ____________

Diagram 16 **Nervous Control in the Representative Organisms**

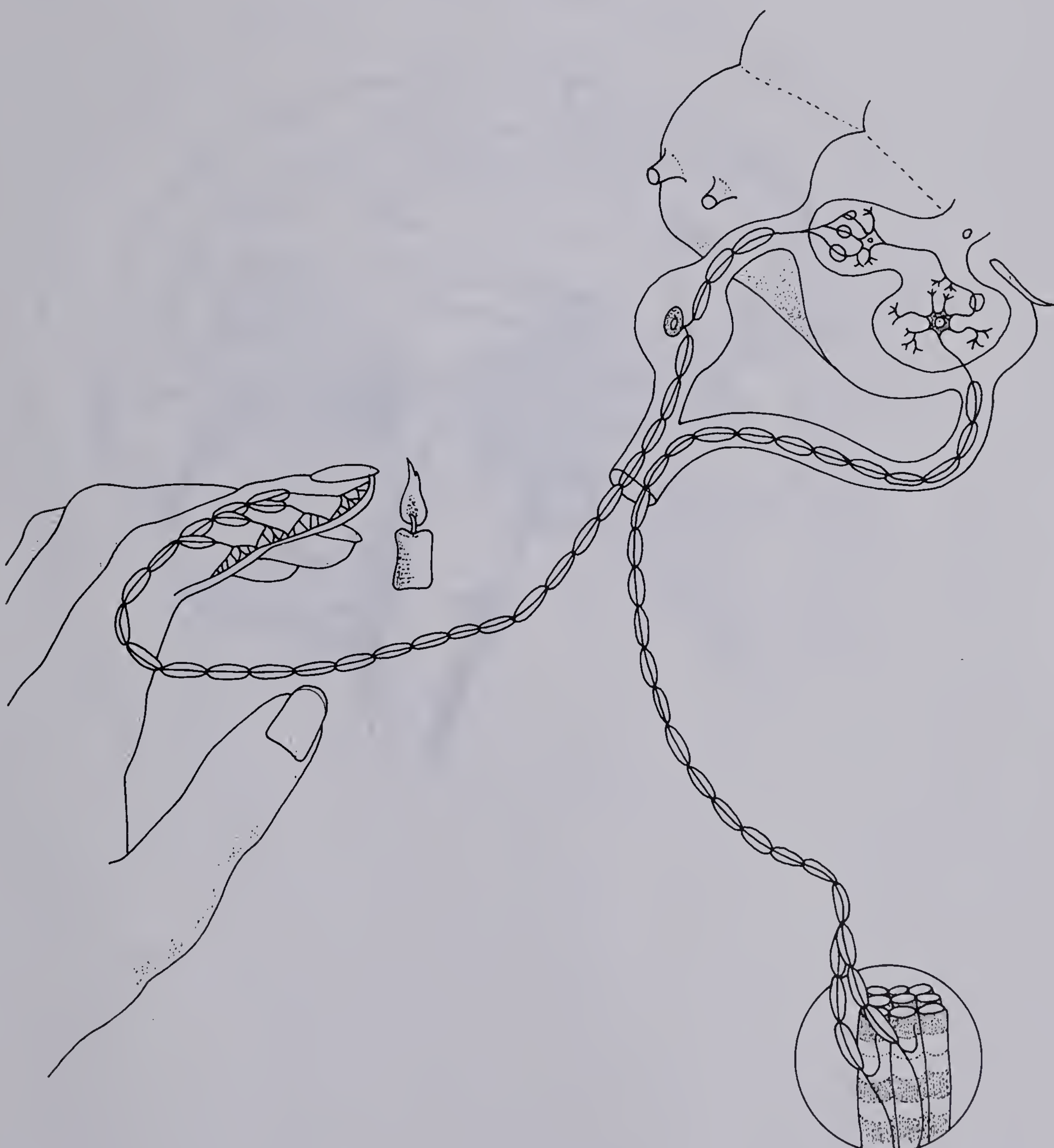






Name ________________________________ Date ______________

Diagram 17 **The Reflex Arc**

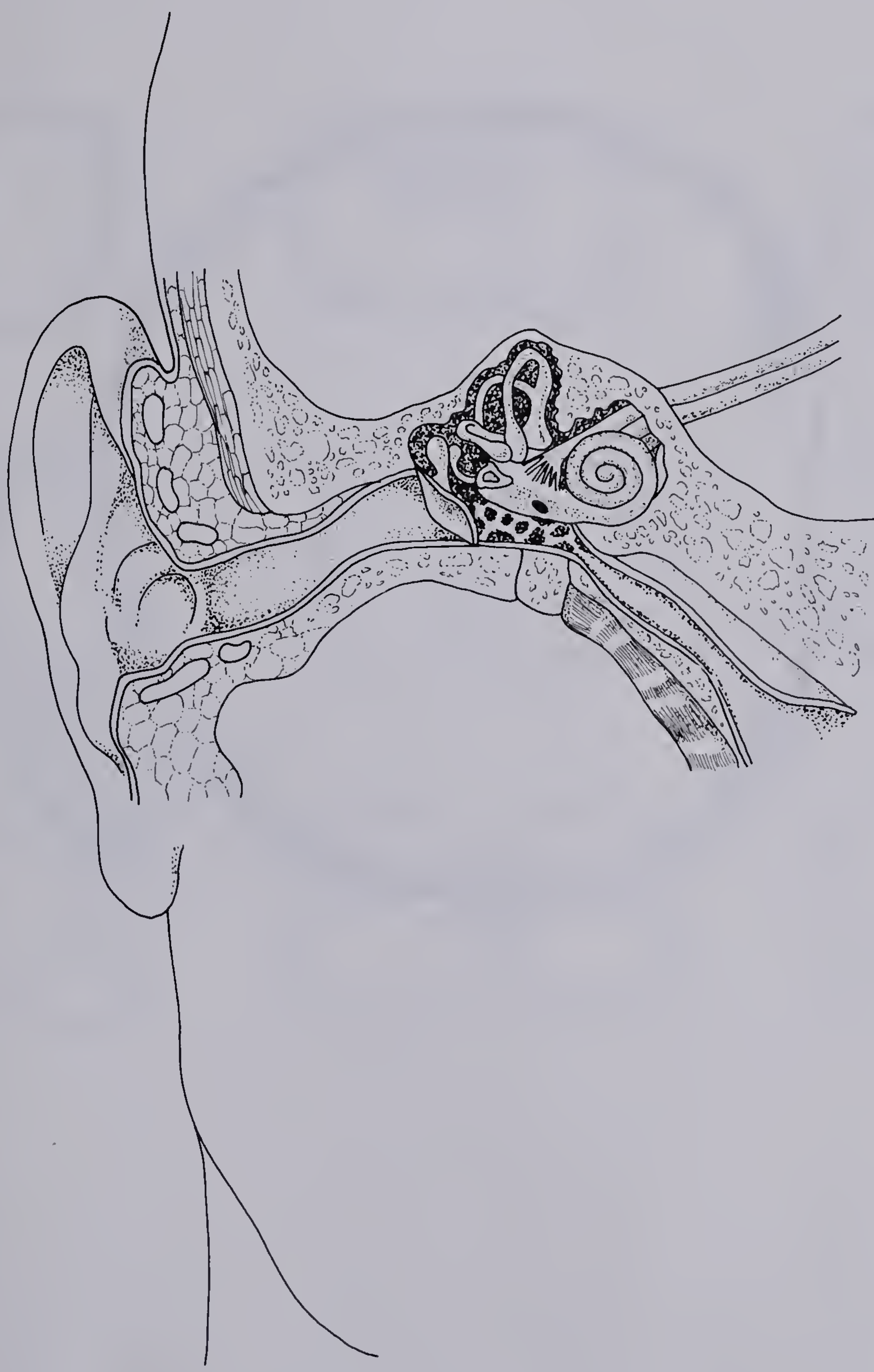


Name ______________________ Date __________

Diagram 18 **The Brain**

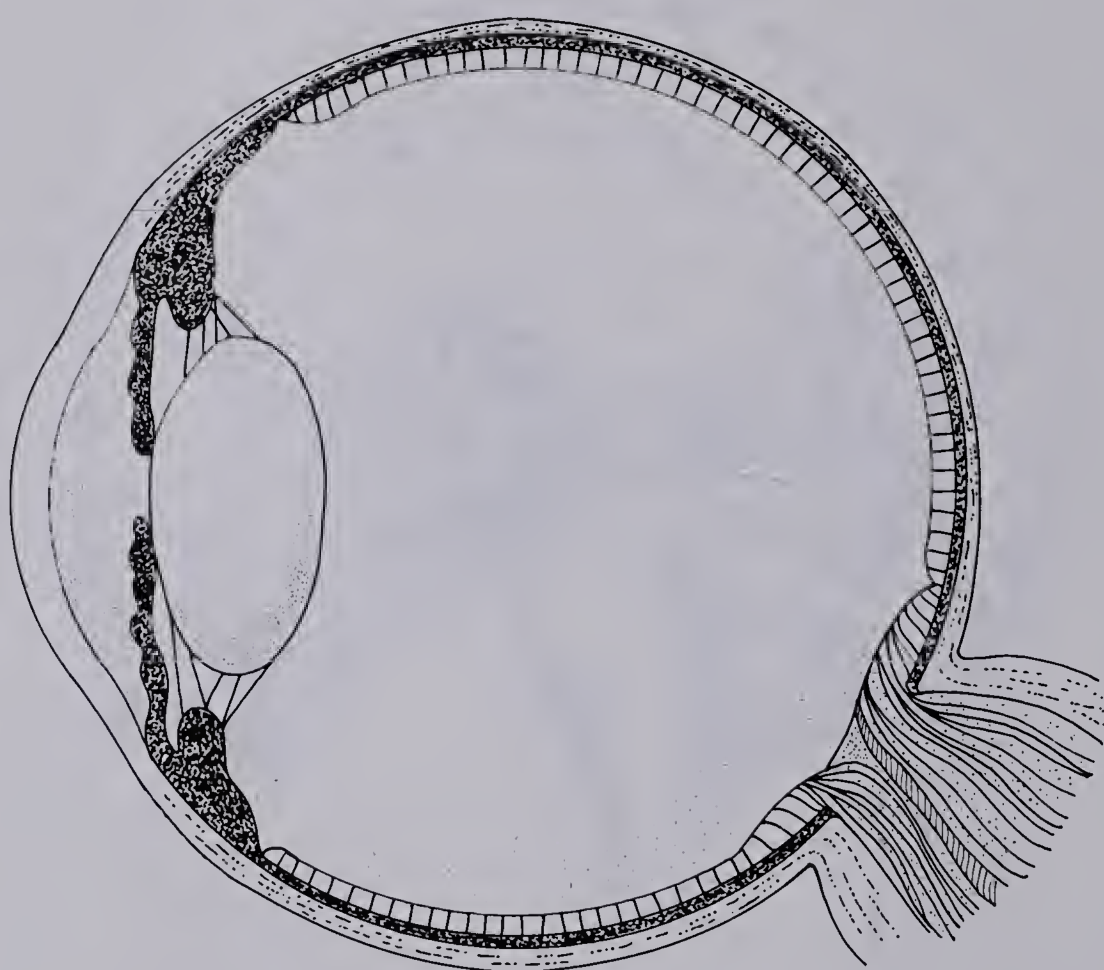
Name ________________________________ Date ____________

Diagram 19 **The Ear**



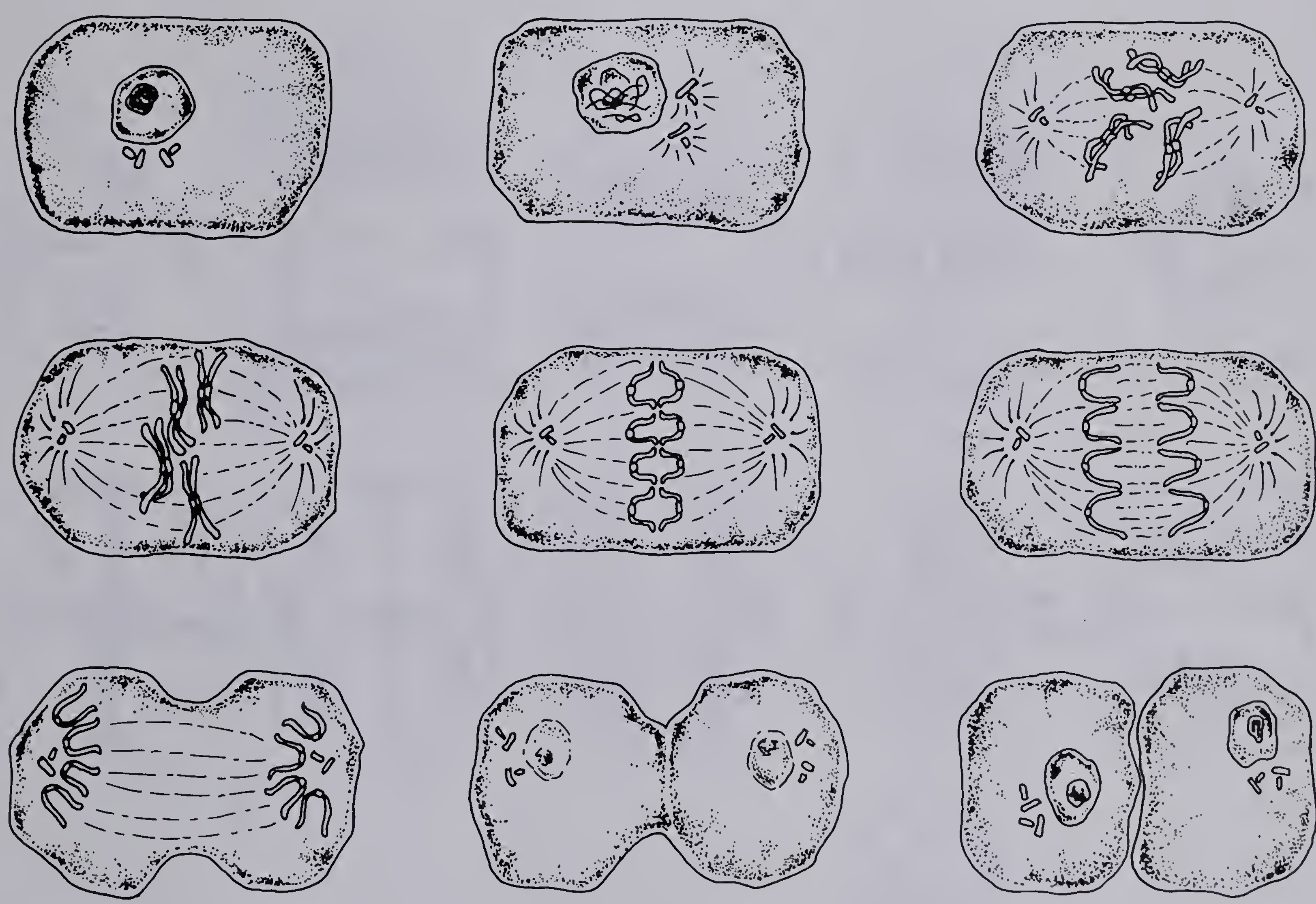
Name ______________________ Date __________

Diagram 20 **The Eye**



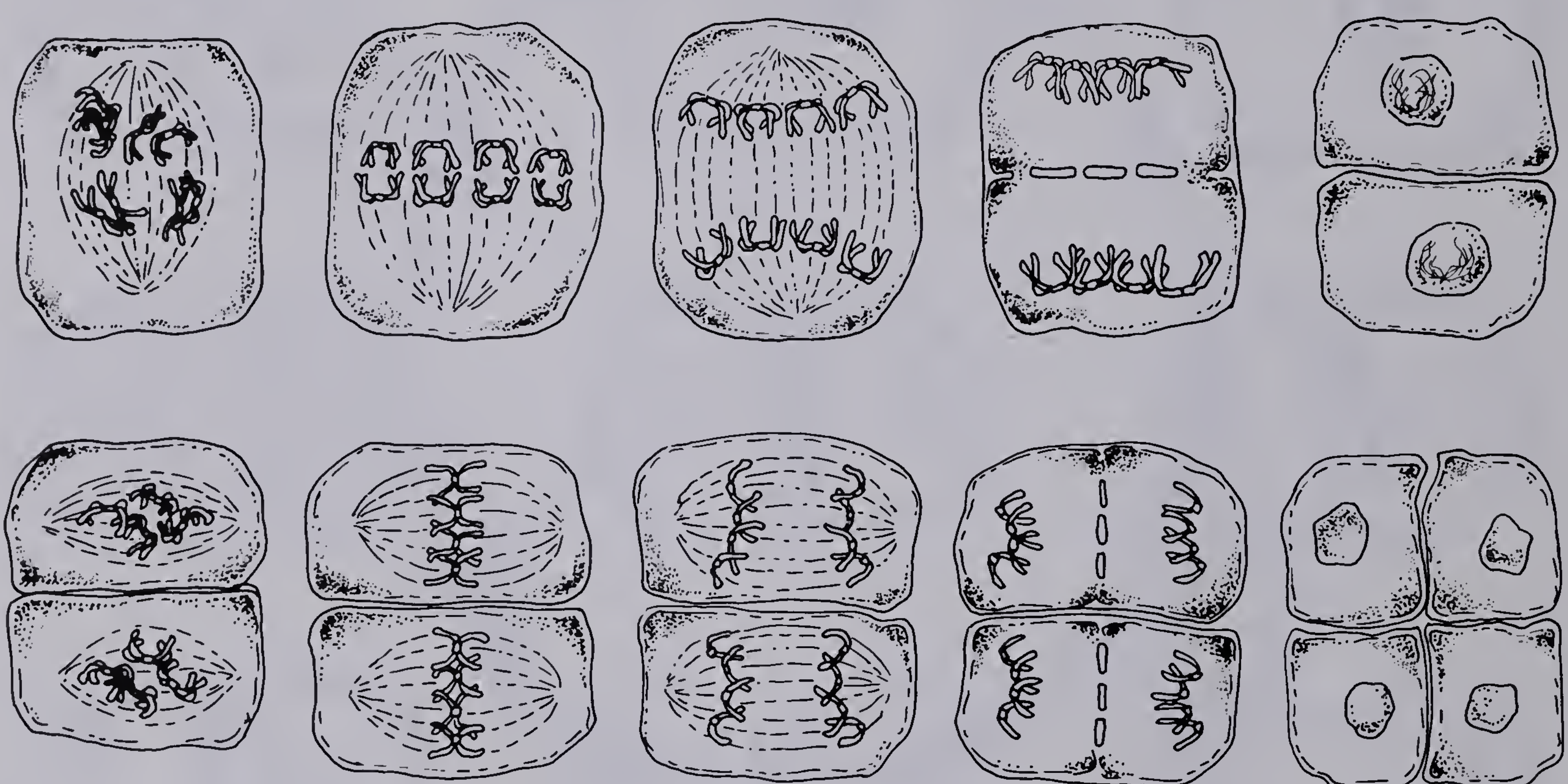
Name ______________________________ Date ______________

Diagram 21 **Mitosis**



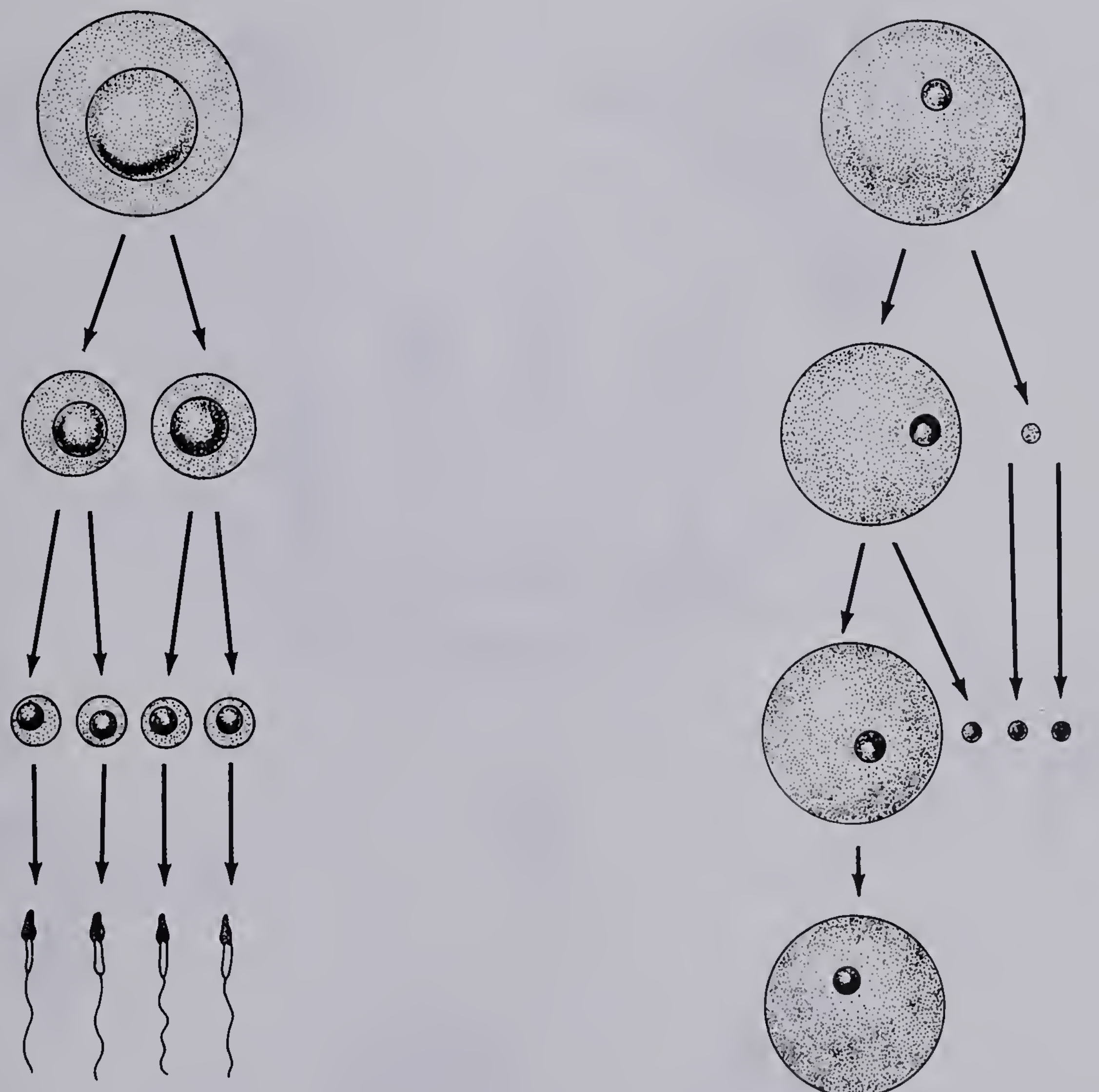
Name ______________________ Date ____________

Diagram 22 **Meiosis**



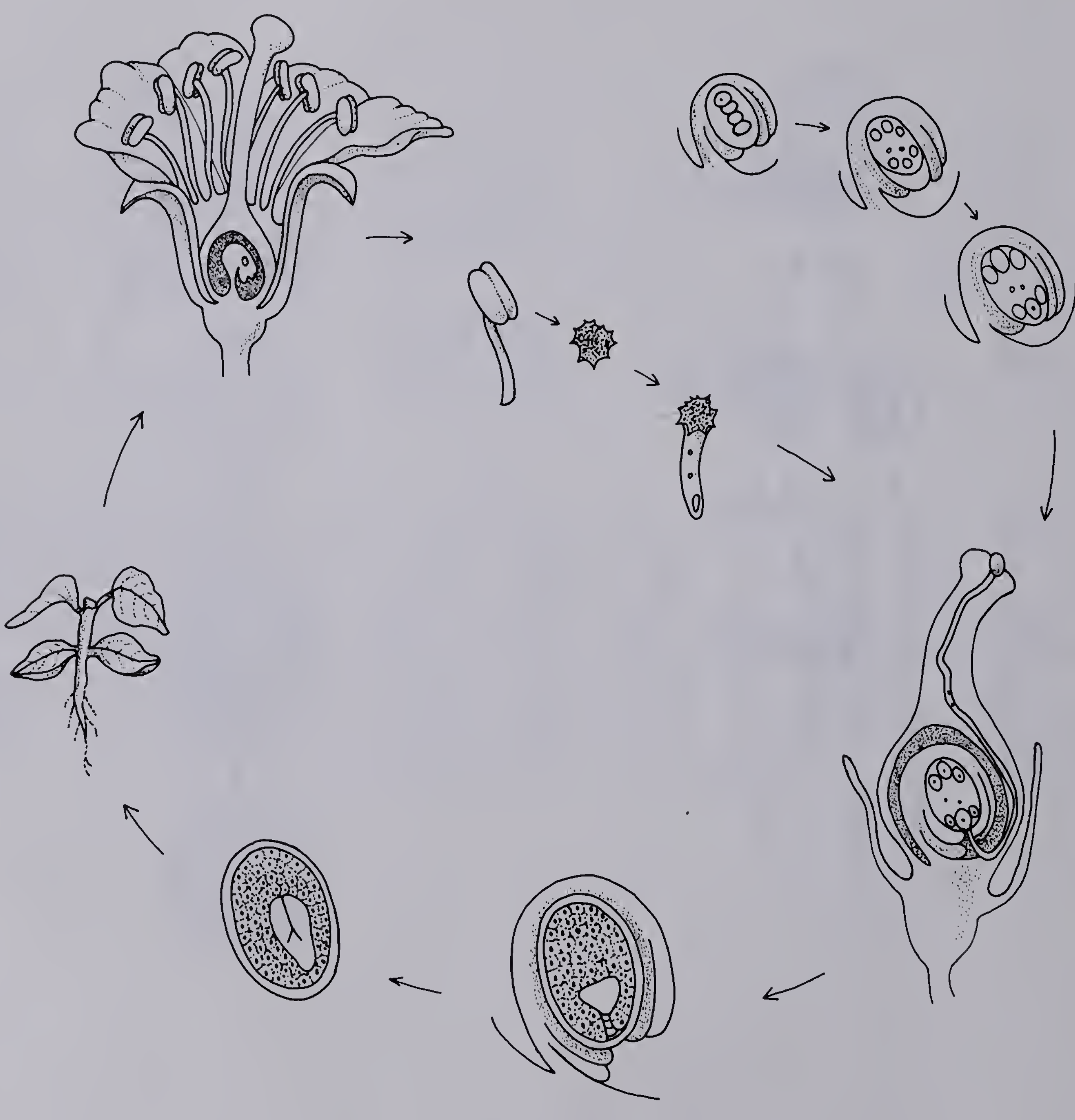
Name ______________________ Date ____________

Diagram 23 **Spermatogenesis and Oogenesis**



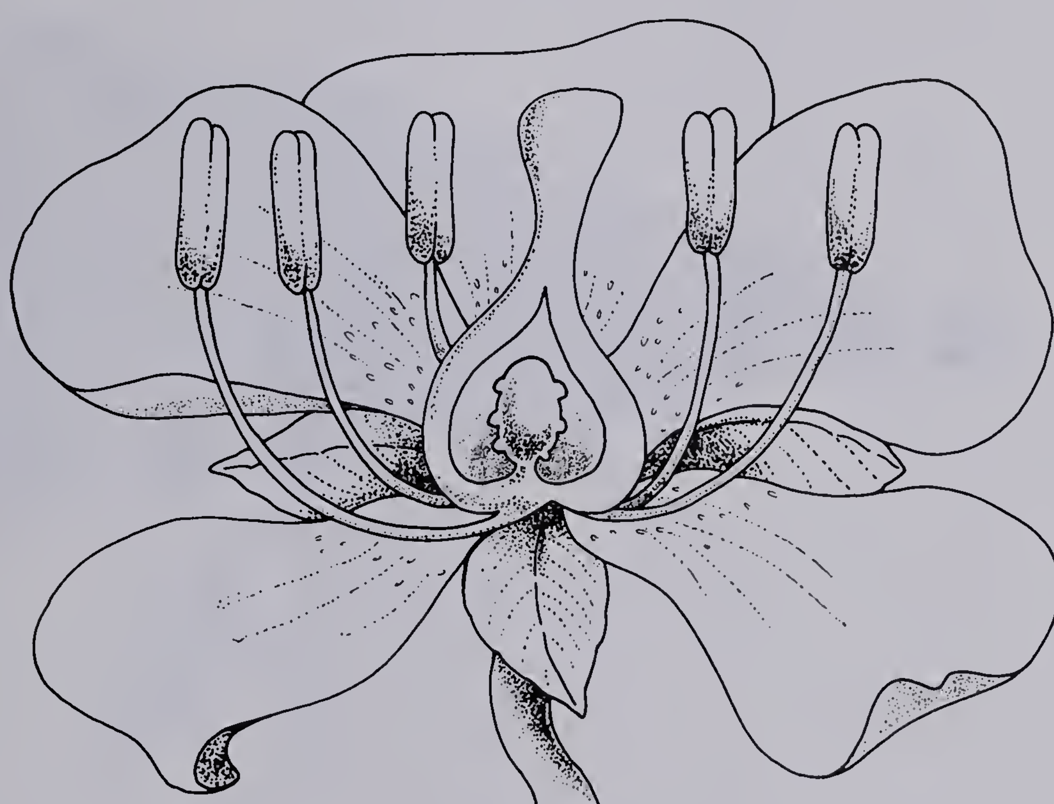
Name ______________________ Date __________

Diagram 24 **Angiosperm Life Cycle**



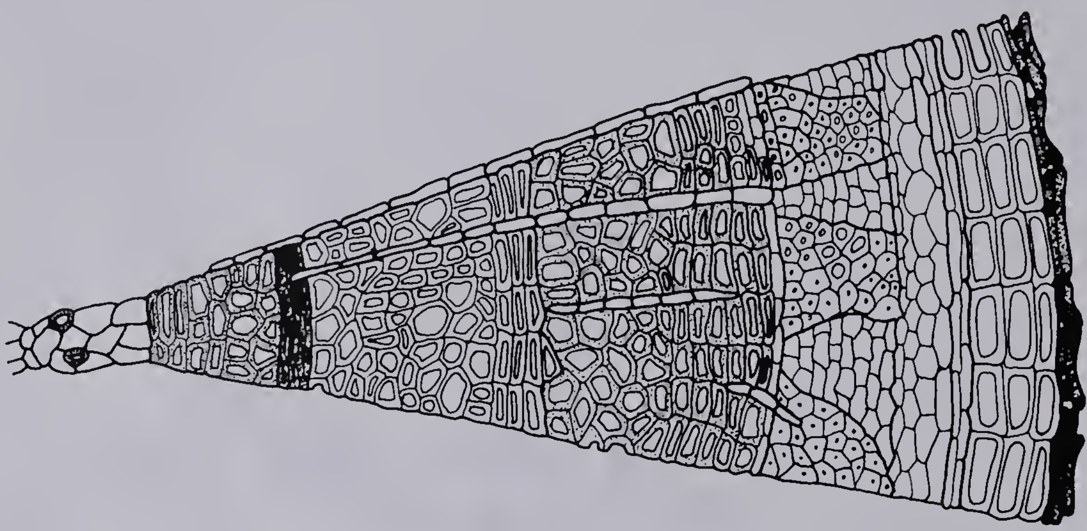
Name ______________________________ Date ____________

Diagram 25 **Flower Structure**



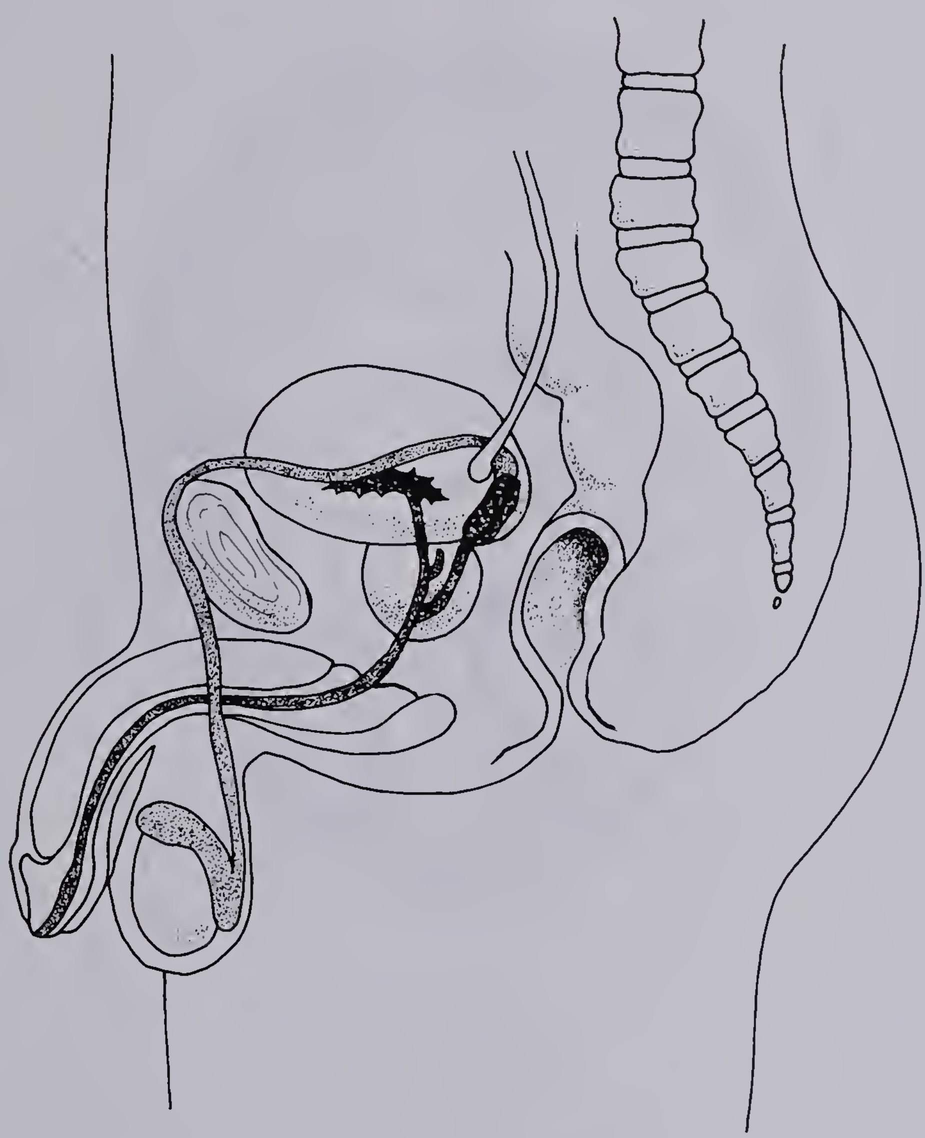
Name ______________________ Date ____________

Diagram 26 **Structure of a Woody Stem**



Name ______________________________ Date ______________

Diagram 27 **Male Reproductive System**



Name ________________________________ Date ______________

Diagram 28 **Female Reproductive System**

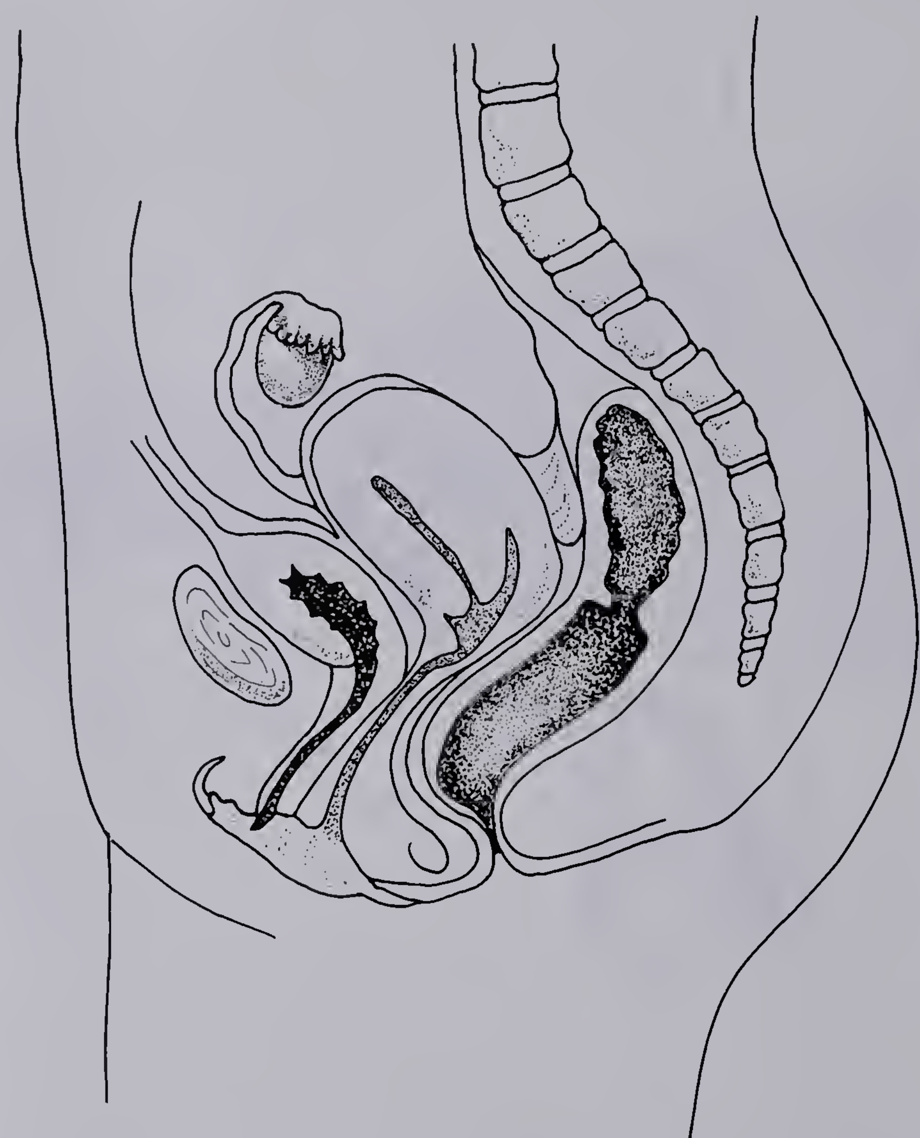


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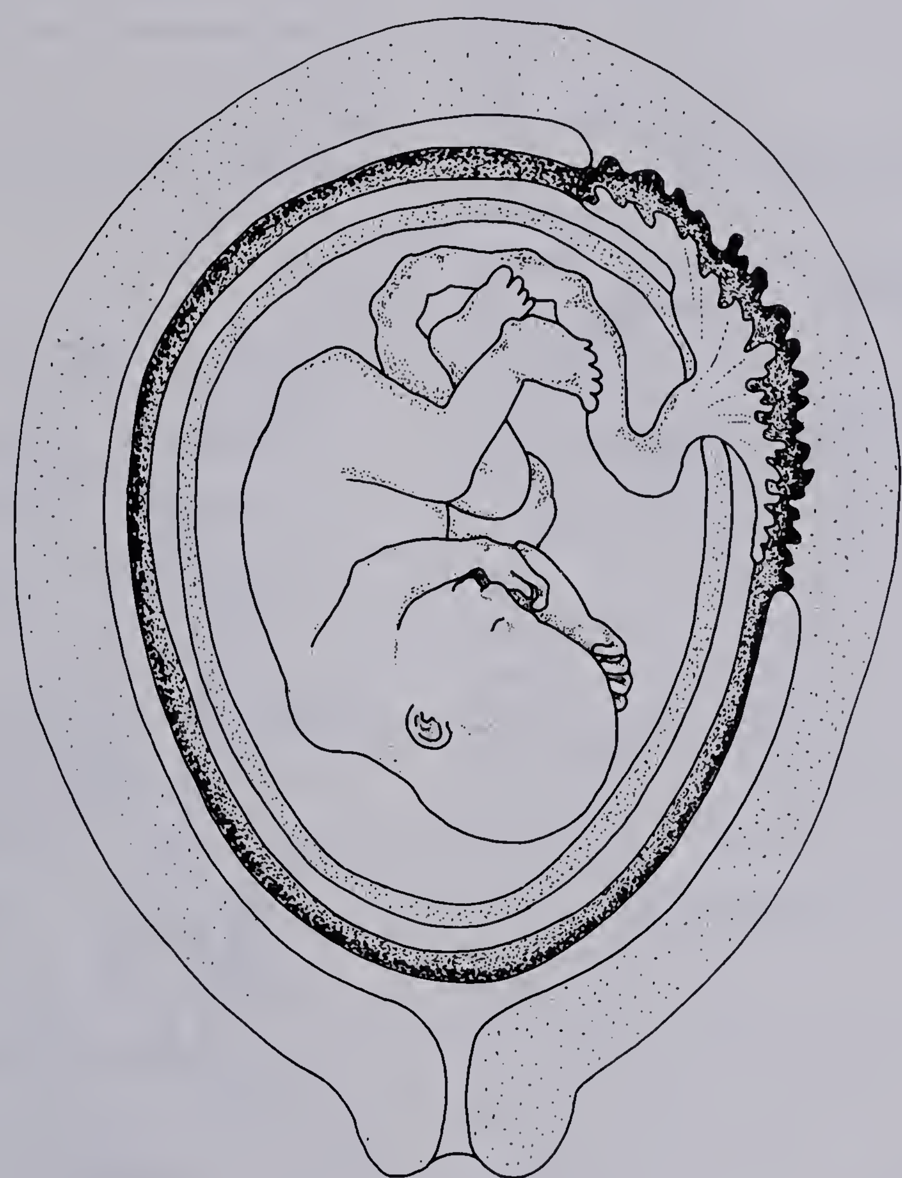
Diagram 29 **Human Development**



Name ______________________ Date ____________

Diagram 30 **Chemical Cycles**

Name ______________________________ Date ____________

Study Skill 1
Reading About Biology

Suppose you came across a seventeenth-century manuscript containing the following paragraph:

Now, I did reason that if life is spontaneously generated in nutrient solutions, then a flask of sterile beef broth left undisturbed for several days should show the presence of small organisms. Accordingly, I prepared and sterilized a flask of broth and, leaving it uncovered, put it aside for a week. Using a microscope, I then examined a drop of the broth, which had become cloudy and putrid, and found it densly crowded with animalcules. My hypothesis thus was confirmed, and I concluded that spontaneous generation of life does indeed occur.

How would you evaluate what that imaginary author said? If you read the paragraph carefully, you will realize that the argument is not logical: while spontaneous generation could have explained the appearance of bacteria in the broth, other things could also account for it, such as microscopic material falling into the open flask. In reading the accounts of scientific experiments, it is important to be alert for such lapses in logic.

As you read a scientific article, look for the hypothesis or premise on which the piece is based. The author's premises can usually be found in the first paragraph or two of an article; the conclusion is usually found at the end of the piece. Ask yourself: What are the author's beliefs about this? What is the author trying to prove, show, or demonstrate? What conclusions has the author come to? Are the conclusions based on a logical progression of ideas and on pertinent data? Does the author consider other ideas, even if they do not agree with his or her own?

Does the author defend his position with logic, or are opposing views dismissed with emotive words and generalities? (Emotive words are those that inspire emotional reactions. These words are usually adverbs and adjectives, such as *tremendously, really, never, always, good, bad,* and so on. It is not necessary to eliminate these altogether, but it is *always* a *good* idea to be aware of them!)

Before reading anything in depth, it is usually helpful to skim through it, picking out the main ideas and making notes in phrase form. This gives you an overview of the author's ideas and helps you focus on the content when you re-read for depth. While skimming, try to identify and write down the premises and conclusions.

Effective Reading An effective reading technique is outlined below. If you master this technique so that it is automatic, you will save much time and energy.

1. Pre-read and skim:
   Read the title.
   Read the subtitles.
   Look at the charts and diagrams.
   Read the first and last sentence of each paragraph.
   Read the last paragraph or summary carefully.

2. Read carefully and take notes.
3. Review the entire piece:
   Read the titles and subtitles again.
   Relate the data and illustrations to the main ideas.
   Read the sentences that summarize the main topic and look for key words.
   Read the last paragraph or summary.

Besides looking for the premises stated by the author, you should watch out for hidden assumptions. Every person has a biased point of view that influences not only the kinds of information chosen to be included, but also the words and phrases used to communicate the ideas. Be aware of words as powerful symbols that can evoke powerful emotions.

Take nothing for granted, not even a scientist's objectivity. No matter how academic the presentation, some information may have been left out purposely or unduly emphasized. Also, a statement may be *wrong.* Like anyone else, authors and editors make mistakes. If you see something that looks wrong, try to verify it or disprove it.

As you read, have a note pad and pencil handy. Write down any question you may think of, whether they pertain to facts quoted in the essay or blatant statements made by the authors. As a small child, you learned about the world by asking questions of your parents and other people in your environment. A good scientist, like a child, never stops asking questions.

Analyze and Evaluate As you read in depth, analyze and evaluate what you are reading. To analyze means to examine critically. To evaluate means to make judgements about the value or worth of something. To help you analyze an article or book about a topic in biology, ask the following questions as you read: What is the author trying to say? What is the purpose of the article? Is the author's reasoning sound? Are the facts accurate? What are my reactions as I read? Does the author appeal to my emotions or reasoning ability? Paying attention to facts and how arguments are presented will make you a more informed and critical reader.

To evaluate your readings, you must first analyze them. The more thorough the analysis, the more solid your foundation for evaluation. Evaluation is a subjective task because you bring your experiences, feelings, and preferences to bear on the information you have gathered. If you are well-informed, the arguments you use to support your preferences will be sound.

Here are some questions to help you evaluate many readings in biology:

How does the author's subject and focus relate to current concerns about human beings in relation to the world?

How does the author's intention relate to my beliefs?

Am I willing to consider the validity of the author's arguments even though I disagree with the premise? (If you can say yes to this one, the author has presented an excellent case and you will need to re-examine your own ideas thoroughly.)

Reading Skill Exercise Below are opening paragraphs of an article that might have been written for a popular biology magazine. Using the reading skills just outlined, criticize the paragraphs by answering the questions that follow.

"Was Venus a Victim of Pollution?"

It has recently been suggested that if all life on Earth were destroyed, the atmosphere would slowly begin to change until finally it becomes like the atmosphere of Venus or Mars. Even small changes in the composition of the gases that make up the atmosphere may eventually have global effects.

For instance, just in the past century the percentage of carbon dioxide in the Earth's

atmosphere has increased 15 percent, primarily due to the burning of fossil fuels, which uses up an equal percentage of oxygen at the same time. Soon there will be no more oxygen in Earth's atmosphere. The use of the atmosphere as a garbage dump for industrial smoke, jet and automobile exhaust may cause irretrievable damage.

A recent probe into the atmosphere of Venus sent back information that flabbergasted the scientific community. The data revealed a high concentration of lethal gases, such as carbon monoxide, surrounding this lifeless planet.

It is my belief that Venus may have once been populated with living organisms as Earth is now and that the Venusian atmosphere was polluted by its inhabitants to the point of ruining the chances for life to survive. Probably a future landing on Venus will turn up signs of a once flourishing civilization. It looks as though our magnificent planet Earth might be as dead as Venus some day.

1. What are the author's premises?

____

____

____

____

2. What are the conclusions?

____

____

____

____

____

____

3. Are the author's arguments logical? If not, point out an example where the logic is questionable.

____

____

____

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____

Name ______________________________ Date ______________

4. Is data mentioned that supports the conclusions? Are other interpretations of the data referred to?

5. Are there assumptions and biases that you can detect in the author? What are they?

6. Is the language used by the author appropriate for a scientific article? If not, give examples of words and phrases that are questionable.

7. Does the author address current concerns of human beings in relation to the world?

8. Do your own beliefs or knowledge regarding this subject conflict with the author's premises or conclusions? If so, are you still encouraged to read this article to the end to see whether you might be convinced otherwise?

Name ______________________________ Date ____________

Study Skill 2
Understanding Biological Terminology

When you began to study biology, one of the first things you probably noticed was the need to learn what seemed to be a whole new vocabulary. When you were first confronted with *antibodies, catalyst, enzyme, cholesterol,* and *deoxyribonucleic acid*, you may have despaired of memorizing the meanings of so many new and unusual terms.

The purpose of this activity is to help you recognize common roots, suffixes, and prefixes so that you can dissect a biological term and put together a definition based on the meanings of its parts. An effort made in the beginning to learn the meanings of some common root words will provide a good basis for deciphering each new term.

A key to learning science vocabulary is to familiarize yourself with some basic Latin and Greek roots and affixes. For example, consider the word *osteopathology*. The Greek prefix *ost* or *osteo* means "bone." *Path*, the root, means "disease of," and the suffix *ology* means "study of." Thus, osteopathology refers to the study of diseases of bones. If *geo* means "earth," then what is *geology*? If *cardi* means "heart," then what is *cardiology*? If *anti* means "against," and *bio* means "life," then what does *antibiotic* mean?

Now you begin to see how easy it is to recognize science vocabulary without so much as a glance at the dictionary. Remember that science attempts to be as precise as possible and scientists use technical words because such words usually have one specific meaning.

Included in this study skill activity is a glossary of selected Greek and Latin roots, prefixes, and suffixes. You will use it during the exercise that follows.

Dissecting and Defining Biological Terms
Two sets of words are given below. In the first set, terms are divided into syllables to help you determine the parts that correspond to root science words. The second list contains terms that have not been split into syllables; you must first decide how to split them before looking up the literal meaning of each part using the glossary. In the last part of the exercise you will write a sentence or two expanding the definition of each term.

First, refer to the glossary to find the meaning of each word part and write it down in the space provided. Then expand the definition by writing a sentence or two using the word as it applies to biology.

For example, the term *biology*:

bio - life ______ Biology is the study ______

ology study of ______ of life forms. ______

If you have trouble expanding the definition, you may want to discuss it with another student. Some of the word parts are not Latin or Greek and will not be found in the glossary; use your knowledge of common vocabulary words to determine their meanings.

For example, the term *locomotion*:

loco - place ______

-motion process of moving ______

____

____

In the space above use *locomotion* in a sentence that describes a process in biology. Did you discover why scientists put these word parts together to name this particular process?

Name ____________________ Date __________

Study Skill 2, page 2

Try a few more:

1. ab- ____________ ____________

   -normal ____________ ____________

2. ame- ____________ ____________

   -ba ____________ ____________

3. aero- ____________ ____________

   -be ____________ ____________

4. exo- ____________ ____________

   -skeleton ____________ ____________

5. endo- ____________ ____________

   -derm ____________ ____________

6. hyper- ____________ ____________

   -tension ____________ ____________

7. hypo- ____________ ____________

   -thermia ____________ ____________

8. in- ____________ ____________

   -organic ____________ ____________

9. meta- ____________ ____________

   -phase ____________ ____________

10. ovi- ____________ ____________

    -duct ____________ ____________

A Definitions Exercise In the following exercise you are asked to divide each of the listed words into their basic parts. Using the glossary at the end of this Study Skill, find the meanings of the word parts. Then, for each term write a sentence that expresses the essential scientific meaning of the term.

For each term, blank lines separated by equal signs are provided for writing in the meaning of each word part. In some cases the word parts are common terms for which you will supply the meaning; otherwise, the glossary may be consulted. Be prepared to hand in this exercise to your teacher.

Name ________________________ Date ____________

Study Skill 2, page 3

1. antibody ________ = ________ ________ = ________

____

2. chromatograph ________ = ________ ________ = ________

____

3. chemotherapy ________ = ________ ________ = ________

____

4. chromosome ________ = ________ ________ = ________

____

5. decompose ________ = ________ ________ = ________

____

6. extracellular ________ = ________ ________ = ________

____

7. herbivorous ________ = ________ ________ = ________

____

8. interphase ________ = ________ ________ = ________

____

9. photosynthesis ________ = ________ ________ = ________ ________ = ________

____

10. spermatogenesis ________ = ________ ________ = ________

____

11. taxonomy ________ = ________ ________ = ________

____

12. zoology ________ = ________ ________ = ________

____

Glossary of Selected Greek and Latin Roots

a-, an-	without deficiency	atrophy, abiogenesis
ab-	away from	abnormal
ad-	to, near	adductor
aero-	air	aerobic
ameb-	change	ameba
amphi-	on both sides	amphibian
angio-	case, capsule	angiosperm
antho-, -anth	flower	anther
anthropo-	man	anthropology
anti-	against	antigen, antibiotic
atmo-	breath	atmosphere
auto-	self	autotroph
bi-, bis-	twice, double	biennial, binomial
bio-, -be, -ba	life	biology, amphibian, microbe, aerobe
bot-	graze, feed	botany
bry-	grow	bryophyte, embryo
calori-	heat	calorimeter, calory
capilli-	hair	capillary
cardi-	heart	cardiac, cardiovascular
carni-	flesh	carnivore
celli-	cell	cellular
cerebro-	brain	cerebrospinal, cerebral
chemo-	by chemicals	chemistry, chemoreceptor
chromota-, chromo-,	color	chromatic, chromosome
cocco-	berry	streptococcus
coelo-, celo-	hollow	coelenterate
corpor-	body	corporal, corpuscle
cranio-	brain	cranial, cranium
cuti-	skin	cuticle, subcutaneous
cyto-	cell	cytoplasm, spermatocyte
de-	down, away from, negative	decomposer, dehydration
demo-	people	epidemic
dermato-	skin	epidermis, dermal
di-, dis-	two, twice, double	dicotyledon, dihybrid
dicho-	twofold	dichotomy
diplo-	double	diploid
dorso-	back	dorsal
e-, ex-, ec-	out, out of	exhale
eco-, oeco-, -oeci-	house	ecology
ecto-	outside	ectoderm
en-	in	endemic, embryo, enzyme
endo-	within	endosperm, endocytosis

ergo-, -ergy, org-, -urgy	work	organ, energy
exo-	outside	exoskeleton
extra-	outside, beyond	extracellular
folli-	bag	follicle
ganglio-	knot	ganglion
gastro-	stomach	gastric, gastrula
geno-, -gen	production	genotype, genetic
gono-	seed	gonad
geo-	earth	geology, geotropism
grapho-	write	chromatograph
gymno-	naked	gymnosperm
hemo-, -emia	blood	hemoglobin
haplo-	single	haploid
hepato,	liver	hepatitis
hetero-	other	heterotroph, heterozygote
hiberna-	winter	hibernate
homo-	man	*Homo sapiens*
homo-	same	homozygous
hormono-	excite	hormone
hydro-	water	hydrolysis
hyper-	over, above	hypertension
hypo-	under, below	hypothyroidism
in-	not, without	invertebrate, inorganic
infra-	below	infrared
inter-	between	interphase
intra-	within, during	intramuscular, intracellular
iso-	equal	isogamete
-itis	inflamed condition	arthritis
latero-, -lateral	side	lateral, bilateral
loco-, loca-	place	locus
logo-, -logy	study of	biology, zoology
lyso-, -lysis, -lyte	dissolve, loosen	paralysis, lysosome
meta-	with, after, beyond, change	metamorphosis
micro-	little	microbiology, micrometre
morpho-	form	morphogenesis
nephro-	kidney	nephron
neuro-	nerve	neuron
nocti-	night	nocturnal

Name ______________________________ Date ______________

Study Skill 2, page 5

nomo-, -nomy	law	taxonomy
non-	not	nonessential, nondisjunction
noto-	back	notochord
nucleo-	nut	nucleus, nuclear, nucleic
osteo-	bone	osteology
ovi-	egg	oviduct, ovary
para-	alongside	parasite
phago-, -phage	devour	phagocyte, esophagus
photo-	light	photoreceptor, photosynthesis
phyllo-	leaf	chlorophyll
phylo-	tribe	phylum
phyto-	plant	phytoplankton
plasmo-, -plasm, -plast	something molded	plasma, protoplasm, chloroplast
poro-	passage	poriferan
pro-	before, in front of, forward	prophase
pulmoni-, pulmo-	lung	pulmonary
radio-	wheel, spoke, ray	radial, radioactive, radius
re-	back again	reproduction, reinforcer
reni-	kidneys	adrenal
rhizo-	root	rhizome
semi-	half, partly	semipermeable
somato-, soma-, some-	body	chromosome, somatic
speci-	type	species, specimen
spermato-, -sperm	seed	spermatozoa, gymnosperm
spira-, spiro-	breath	transpiration, respiration

sporo-	seed	megaspore, sporangium
-stasis-, -stat	stoppage, balance	homeostasis
stomato-, stoma-, stomo-,	mouth	stomate, stomach
sub-	under, below, less than	substrate
syn-, sym-	with	symbiosis, synthesis
taxo-	arrangement	taxonomy
telo-	end	telophase
tendo-, teno-	stretching	tendon, tensor,
therapia	nurse, care	therapy
therm-	warm	hypothermia
thes, -tem	setting in order	synthesis, system
trans-	across	transplant
tropho-, -trophe	nourishment	atrophy, autotrophic
tropo-, -trope	turn	tropic, phototropism
ultra-	beyond	ultraviolet
vacci-	cow	vaccine
vaso-	vessel	vascular
ventri-	stomach	ventricle, ventral
vert-, vort-	turn	vertebra
vis-, visu-, vid-	see	vision, visible
-vore, -vorous	eat	herbivorous, carnivore
zoo-, zoon-	animal	zoology, zooplankton, protozoa
zygo-, zygomato-	yoke	zygote, zygomatic

Name ____________________ Date __________

Study Skill 3
Preparing a Research Paper

Writing about a biological topic involves discovering information that is new to you. Then, you have the demanding job of making it interesting and informative to other people.

A research project is written up so that other people can read about your project and understand its importance in a broader context. Providing the context, or background of information relating to your project involves doing library work in addition to laboratory or field work.

Even if your paper is based on your own work in biology, you will need to give your reader background information. For instance, you may have spent many spring sunrises in a marsh, watching male redwings and listening to their territorial calls. When you write a paper on what you observed, you should include some information on territoriality, courtship behavior, and the hormonal control of behavior in birds and especially in the species you studied.

Finding a Topic To find a topic that interests you, try thinking about television biology programs that you enjoyed. Maybe you would like to explore some aspect of oceanography or space biology. Magazines like *National Geographic* or *Natural History* also are good starting places. Your textbook can be helpful, too: look especially for topics that sound interesting and could be explained in more detail.

From one of these sources you should find an intriguing subject or unanswered question. Use that as your broad topic. After doing some reading you can narrow it down to a specific topic.

Planning a Writing Schedule Planning how much time to spend on each stage only takes a few minutes, but it is very important if you want to meet the deadline for turning in your paper. Use the steps below to plan your schedule. The suggested times are based on the actual time spent by a high school student writing a ten-page paper on the Neanderthals, a type of early human:

1. Using the library, assembling information	2 weeks
2. Listing major points, outlining paper	1 week
3. Writing rough draft	1 week
4. Revising rough draft	1 week
5. Writing final paper	1 week

This schedule is only a general guide; you may want to allow more or less time for your paper. Using a calendar, establish a deadline for each of the five stages, working backward from the date when your final paper must be turned in. (Leave yourself a few days' leeway.)

Using the Library List a few key words or phrases to use in looking up information on your topic. The student who wrote the Neanderthal paper, for example, began with the key words *Neanderthals* and *evolution, human*.

These key words can be used as entry points into the card catalog, the *Reader's Guide to Periodical Literature*, and *Biology Digest*. Your library may have other useful biology references; be sure to ask the librarian.

Assembling the Information Use 3″ × 5″ index cards to copy down the references you find. To save time later (when you prepare the bibliography of your paper), copy down the author's name and the title of the book or article along with the library accession number or journal reference. The cards should look like this for books:

Name ______________________________ Date ____________

10	code number
Kennedy, K.A.R.	author
Neanderthal Man.	book title
Minneapolis:	place of publication
Burgess Publishing Co.,	publisher
1975	date

And like this for journals:

11	code number
Brace, C.L.	author
Refocusing on the Neanderthal problem.	title of article
American Anthropologist	journal name
64:	volume
729–741,	inclusive pages
1962.	year

Notice the code number on each card. When you look up the references indicated on the cards, you will want to take notes or in some cases, make photocopies of several pages. Putting the reference code number at the top of each page of notes or copy indicates which reference is the source of the material.

Do not spend a great deal of time taking notes from the references. It is better to spend your time reading the material for understanding, then jotting down a few main ideas. When you finish reading an article or book section, be sure to check and see if there is a bibliography included. You will probably find additional references to consult. Watch for additional keywords, too.

Writing the Paper Your pages of written notes and photocopied pages will probably cover a very broad range of material. At this time, you should narrow down the topic somewhat. The student who planned to write about Neanderthals had collected material on evolution in general, on the neuromuscular basis of speech, and on the Ice Ages. He decided to focus his paper on the mysterious disappearance of some of the Neanderthals. That meant setting aside the notes that he probably would not need and arranging the remainder for maximum usefulness.

Decide on the major points you want to make in the paper. For example,

1. Neanderthals disappeared from southwestern Europe about 35 000 years ago.
2. Some scientists think the Neanderthals' disappearance was connected with an inability to speak.
3. Neanderthals may have interbred with more modern humans. If so, they are among our ancestors.

Deciding on the major points is often the hardest part of writing a paper. If your notes are insufficient, go back to the references and do some more thinking and research on the topic.

The Outline Now you can arrange your notes into categories covering each point you plan to discuss. Construct a simple outline of the paper, using the major points as a guide. Estimate how much space will be given to each section.

For example,

Who Killed the Neanderthals?

A. Introduction (story about Le Moustier, one of the Neanderthal fossils) ½p.
B. The People Who Vanished (description of the Neanderthals' way of life, disappearance) 3pp.
C. The Importance of Speech (hypothesis that Neanderthals had no speech; evidence and arguments) 3pp.
D. Another Hypothesis (possibility of interbreeding with more advanced humans) 3pp.

E. Who Cares about the Neanderthals? (scientific curiosity, extinction mechanisms, human ecology, and history) ½p.

The outline above is rather loose, reflecting a blend of speculation and scientific reporting. You may find it easier to present the same information in a more traditional, outline form:

A. Background (stages in human history)
B. The Neanderthals
C. Physical characteristics
D. Ecology
E. Disappearance

If your paper is to include artwork or photos, plan them along with your outline. (The student writing about the Neanderthals decided to sketch a Neanderthal skull displayed in a local museum.)

The Rough Draft The next stage of writing is the rough draft. For a rough draft, it is better not to worry about spelling, exact wording, or punctuation. Concentrate on getting your ideas on paper. When you use a direct quotation or refer to a library source, put the source's code number in parentheses at the end of the quotation or reference. Be sure to give a figure number to each planned photo or piece of artwork and refer to it in the rough draft as (Figure 1) etc.

Put aside the completed rough draft for a day or so. When you re-read it, try to be more critical of it than any other reader would be. Circle confusing sentences and terms that should be defined; write comments and questions in the margins.

To make corrections in the rough draft, you may have to go back to your notes or to the original sources. Clear up all the problems that have emerged. Do sketches for artwork, take photos, and write captions for both artwork and photos. There should be a clear connection between the text of the paper and all the illustrations.

Depending on how much revision is needed, write one or more further drafts before doing the final draft. Before typing or writing the final draft, correct errors in punctuation and spelling.

The Final Draft When you write the final draft, replace the parenthesized code numbers with authors and date in correct biology style; for example: (Stone, 1984). A reader who wants complete source information can refer to your bibliography.

Complete your preparation of artwork, photos, and captions and insert them into the text close to relevant text. Type the final draft or write it neatly and legibly in ink. Doublespace the lines and leave margins of about 3 cm. Number the pages in the upper right corner and neatly correct minor errors. You may wish to include a cover sheet with just the title, your name, the date, the class and teacher.

The Bibliography To write the bibliography, remove any index cards that were not used for the paper. Then rearrange the remaining index cards according to the authors' names, and type the bibliography in that order. Use all the information on the index cards. A commonly used style in writing bibliographies follows:

Brace, C.L. Refocusing on the Neanderthal problem. *American Anthropologist* 64:729–741, 1962.

Kennedy, K.A.R. *Neanderthal Man.* Minneapolis: Burgess Publishing Co., 1975.

Name ______________________________ Date ____________

Study Skill 4

Making Observations

Can you recognize and name these birds from their flight postures? If you are an astute and well-trained observer, you would have no trouble distinguishing bird species by this kind of characteristic. You would know immediately that the silhouettes, from left to right, represent a crane, a heron, and an ibis.

In this activity, you will sharpen your observation skills by choosing a species of bird found in your area and observing it for a period of two weeks.

Watching birds is an ideal way to see the principles of ecology in action. Many biological investigations focus on birds because they are often the easiest part of the environment to study. Birds are also excellent indicators of environmental quality. Declines in bird populations alert scientists and the public to changes in the environment. The ban on DDT and other pesticides was enacted primarily because of the severe effects that repeated spraying had on birds that ate the insects and fishes contaminated by these chemicals.

Getting Ready to Observe Before you begin your observations, you will need the following materials: a small notebook, binoculars with a central focus (these do not have to be expensive), and a field guide to help you identify the birds you find.

A good field guide illustrates all the birds found in the area it covers and describes identifying marks, habitat, voice, and range. Before beginning your observation, study how the species are arranged in the book and what birds to expect in your area during each season. If you live in the eastern half of North America, you may want to use Peterson's *Field Guide to the Birds.* Peterson's *Field Guide to Western Birds* covers the western half of North America. *Birds of North America* covers species for the whole continent.

Since birds are often not easy to see with the naked eye, using a pair of binoculars is a must (7×35 and 8×40 are recommended powers).

To locate objects through binoculars, here is a helpful hint: Start by focusing on objects that do not move and you will learn what adjustments have to be made to see clearly at any distance. When you see a bird, keep your eye on it while raising the binoculars to your eyes.

Bird watching is not restricted to the countryside. You can observe birds in city parks, cemeteries, or in your back yard. The best time to be in the field is early morning. Birds are more active at that time and are therefore easier to find. Birds rest at midday and early afternoon and are active again at twilight.

What to Look For Refer to your field guide and choose a species that is common to your area and can be easily observed. Be sure to write down in your notebook everything you see, noting the date, time of day, weather conditions, and other environmental factors. Use a summary table, such as the one shown, to organize your observations. Note how the birds set up and defend their territories, find mates, interact with others of their species, feed, build nests, and care for their young. Watching a few pairs of the same species will tell you about general patterns of behavior as well as individual variations.

Once you have located a bird species, first consider the type of habitat in which it is living. Then examine the general outline and size of individual birds. You may even want to make a rough sketch in your

notebook. Bird identification is mainly based on distinctive coloring and markings. Does the bird have solid patches of color, streaks, bars, a combination? Is there a stripe running through the eye? A ring around the eye? Stripes near the shoulder? These are some markings to look for. Although it is difficult for beginners, with practice and a good field guide, you can soon master identification of most of the birds in your area.

Now, look carefully at the colors of the feathers. These colors sometimes have a function separate from communication or protection. For example, the black wing tips of many large white birds—snow goose, wood stork, whooping crane, and many gulls—contain a pigment that functions to make that part of the feather more durable. The pinkish color of many desert birds not only provides some camouflage but also helps insulate the bird's body from strong light and the extremes of heat and cold found in desert climates.

Listen carefully to the bird's song. The song of each species usually follows a set pattern, while allowing for regional and individual variation. Bird songs contain many more notes than the human ear ordinarily hears. You may want to record a bird's song on tape and play it back at slow speed to hear some of these other notes.

Birds sing to maintain their territories, advertise mating availability, and communicate other messages. Notice the variations in volume of a bird's song. Songs communicating territorial ownership or availability are loud. Songs directed at a mate within the territory are not as loud, and songs associated with courtship are very soft.

Aggression, alarm, danger, and food location are other kinds of information that birds convey vocally. Usually these are communicated through short, unmusical notes, or calls. See if you can identify some of the calls made by the birds you are observing.

If you have trouble locating a species, you may want to put up a bird feeder in your yard or outside your home. This will attract some common species in your area and will make it easier for you to observe individual birds.

When you have finished making your observations, write a report of everything you learned about your bird.

Summary of Observations

1. Date: ____________________

2. Time of Day: ____________________

3. Weather conditions:

____

____

4. Brief description of habitat or environment (woodland, marsh, open field, plant life, etc. Also the name of the location):

____

____

5. Rough sketch of outline of the bird (include an estimate of size and note the shape of the bill):

6. Description of color and markings (include a description of particular feathers from tip to tip):

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7. Other comments and observations:

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____

Name ______________________ Date ____________

Study Skill 5
Planning Experiments

If you grow house plants, you have probably encountered some unpleasant surprises. A plant that seems healthy one day may be droopy, yellow, pale, or covered with insects the next. And for each problem, there are a variety of factors that may be responsible—amount of water, fertilizer, or light; temperature; even your salad-loving cat. (Such factors are called variables.)

Suppose one of your house plants has a few yellow leaves, some of them even turning brown around the edges. You could speculate that there is too much water, too little water, too much plant food, and so on, and haphazardly try to solve the problem by concentrating on one variable after another. This method, of course, is unscientific because you would never be sure what factor or factors were responsible.

Determining the cause of the problem can be approached as a laboratory research project. First, you need information. Consulting at least one reference book about caring for house plants will give you enough background knowledge so that your questions, experimental methods, and observations will be useful and informed.

Suppose that, according to your references, too much plant food will cause yellowing of the leaves. You make the tentative hypothesis that "Too much plant food causes leaves to turn yellow."

Your next step is to put the hypothesis into a testable form:

If (hypothesis), *then* (expected experimental result). In this case, you might write:

> *If* too much plant food causes leaves to turn yellow, *then* experimental plants given too much plant food will turn yellow, and control plants will not.

Methods The core of a well-run experiment is in the procedures that are set up. You must be sure that it is controlled so that only ONE experimental variable is being tested at a time. In this case it will be the amount of plant food. All other aspects of the experimental design must be kept constant.

Using your hypothesis and prediction, carefully list the steps to be taken in testing the hypothesis. For example, you might plan your experiment as follows:

Hypothesis: too much plant food causes leaves to turn yellow.

Method:

1. Take four plants of exactly the same species at the same level of growth.
2. Pot them in identical soils and in identical containers. Number the plants from 1 to 4.
3. Place the four pots where they receive equal amounts of daylight and darkness.
4. Be sure they all receive equal amounts of water.
5. Feed and water all the plants at the same time.
6. Give plant 1 no food.
   Give plant 2 the recommended amount of plant food.
   Give plant 3 twice that amount.
   Give plant 4 three times that amount.

Now take a sheet of paper and list all of the controls in this experiment. What is the variable?

Making Observations Making accurate observations and collecting data precisely is necessary if you are going to achieve reliable results. You will need a notebook to keep records of your observations. These may be written descriptions or drawings. You may decide to observe the plants at regular weekly intervals for two months.

Write the title of the experiment and include the date and time of each observation. Be sure to write down everything you see, no matter how insignificant it seems at the time. Even negative statements can be useful.

For example:

Plant 1: The leaves are turgid and the plant is developing sprouts. There are no signs of withering or yellowness in the leaves.

Plant 2: Some leaves are turgid but others are slightly limp.

You may want to include drawings of the shapes of individual leaves and even of whole plants, emphasizing details of health and vigor levels. You may want to take leaves from each plant and look at them through the microscope, making notes and drawings of what you see. The important thing to remember is to be as accurate as possible in your descriptions and drawings.

The procedure should be well thought out and written in detail before you begin to set up your experiment. It should be clear and precise enough that anyone reading it will be able to repeat exactly the same experiment and get the same results.

Presentation of Results Once you have decided what it is you are looking for, you should be able to design ways to present your results when the experiment is finished. Which methods of presentation do you feel will be most useful for communicating your data? Statistical graphs? Histograms? A written description? Drawings? Diagrams? A combination of two or more of these? If you can think in terms of how you plan to present your data, you will develop more precise skills of observation as you proceed in the experiment. If you wish to include drawings in your results, for example, you should include them in your notes as you make observations.

Conclusions When all the data has been presented and analyzed, conclusions may be drawn about what the results show. Usually it is fairly obvious as to whether or not the data supports the hypothesis made at the very beginning. Be precise in stating how close results are to what was expected.

Questions Resulting from the Experiment A basic tenet in science is the idea that every piece of information or scientific discovery or experimental result provides a basis for learning more about that which is being investigated. One accomplishment in science leads to another. Often experiments will disprove or upset already held theories. In many cases, the results of one experiment may suggest other possible experiments or approaches to the same problem. Scientists must be flexible enough to work with uncertainty and be ready to accept the fact that their theories may be disproven. As science discards erroneous assumptions and gains new knowledge and understanding, it gradually moves towards an accurate and complete picture of the world.

Writing Up an Experimental Design Now it is your turn. Look at the illustrations on these pages in your textbook: 320, 321, 322, 323, 328, 329, 332, 353, 359, 361, 363, 405, 407. Do not read the accompanying text, but use your imagination to pretend that these scenes are totally unfamiliar to you, as if you had just come to earth from some faraway planet. Choose one of the illustrations and devise a hypothesis about the subject that you feel could be tested. Using the chart below, outline your experiment and make predictions based on possible outcomes. Remember, your hypothesis should be stated in very specific terms and then condensed to an "If-------- then --------" statement.

Experimental Design

Hypothesis:

____

____

____

Name ______________________ Date __________

Study Skill 5, page 3

"If -------- then --------" statement:

____

Method:

(Include details and number each step.)

____

Expected observations:

____

Means of presenting results:

____

Results:

____

Conclusions:

____

Questions resulting from the experiment:

____

Name ______________________________ Date ____________

Study Skill 6
Graphing Data

"In general, Sir, ladies should not be allowed to attend our institutions of higher education. The time and expense would be wasted on these ornamental but intellectually inferior creatures, who would do better to employ themselves in cooking, sewing, and other tasks that will make their husbands' lives more comfortable and agreeable."

Though it may seem incredible now, such ideas were expressed repeatedly in the nineteenth-century by men who not only tried to prevent women from receiving college educations, but also presented evidence to support their argument that women are less intelligent than men.

Their evidence consisted of indirect measurements of brain weight. (Human skulls were collected and the braincases were filled with birdshot as a way of estimating brain volume; brain weight then could be inferred from volume.) The brain-weight data were collected as indicators of intelligence in men and women. The heavier the brain, so the argument went, the more intelligent the individual.

Of course, there is variation in most physical characteristics. It is obvious to even casual observers that some individuals of each sex have larger skulls than others. To compare a variable characteristic in two groups of humans, it was necessary to collect measurements from many individuals and to compare the results.

Suppose you repeated the experiment and collected the data below from indirect braincase measurements of 30 men and 30 women:

Estimated Brain Weights in Grams

Men		*Women*	
1295 g	1280 g	1194 g	1105 g
1492	1222	1131	1169
1178	1230	1077	1334
1302	1157	1215	1176
1330	1240	965	1274
1485	1118	1289	1339
1347	1185	1429	1203
1412	1310	1083	1386
1391	1530	1233	1150
1268	1062	1139	1290
1438	1208	1217	1181
1313	1380	1212	1248
1150	1372	1017	1059
1253	1277	1391	1320
1322	1453	1049	1125
mean = 1300 g		mean = 1200 g	

The mean, or average, values are found by adding all the values for men or for women and dividing by the number of samples, in this case 30. Certainly the mean value for men is higher than for women. But mean values can be affected by a few high or low measurements. A better idea of the values for this sample of 60 measurements can be gained through a histogram, or bar graph.

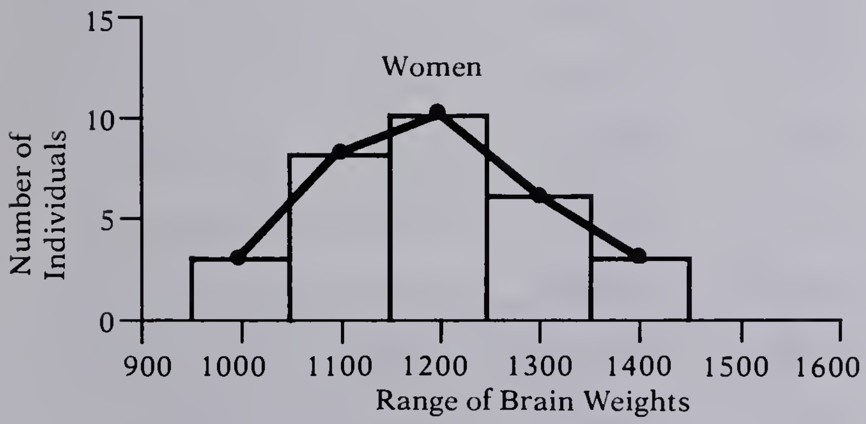
A histogram is a graph made up of bars whose widths represent different ranges of a frequency (such as number of offspring produced in a year: 1–5, 5–10, 10–20, etc.) and whose heights correspond to numbers of individuals, or frequencies, occurring within each range (such as three birds out of 30 produce 1–5 offspring per year; 10 of 30 produce 15–20 offspring per year). Each bar refers to a particular range and the number of individuals falling within that range.

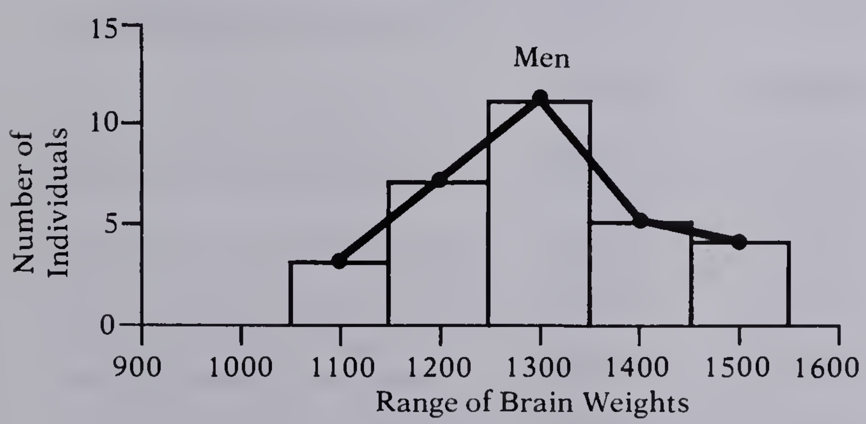
Compiling the Data To make a histogram you must first divide the data into ranges and then count the number of individuals that fall within each range. The table below

was compiled based on the raw data on brain weights determined for 30 men and 30 women.

Range of brain weights	*Midpoint*	*Number of men*	*Number of women*
951–1050	1000	0	3
1051–1150	1100	3	8
1151–1250	1200	7	10
1251–1350	1300	11	6
1351–1450	1400	5	3
1451–1550	1500	4	0

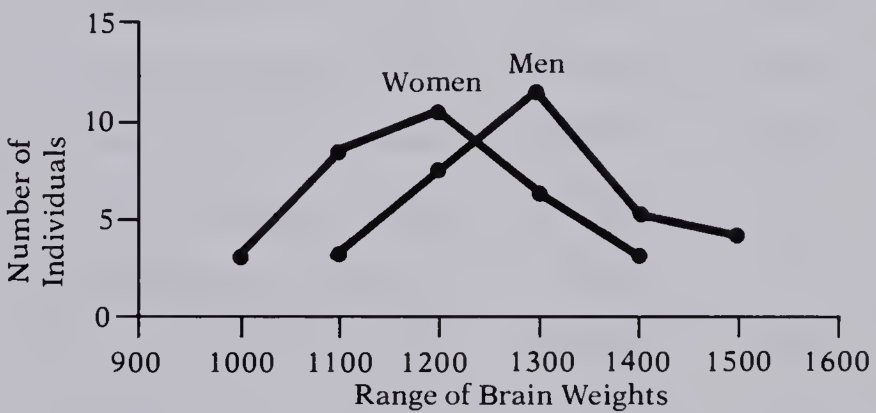
Notice that for each range, there is a center, or midpoint. This figure will be used to draw a line graph from the histogram by connecting the midpoints at the tops of each bar. The following histograms were drawn from the data in the table above. The data for men and for women are each represented in a histogram.





Each bar represents the number of individuals in a certain range. For example, the left bar on the graph for men shows that three men had brain weights in the 1051–1150 g range.

For comparison, the two line graphs can be combined:



Graphs Combined

As it turns out, the graphs do support the contention that, if this sample is typical, men's brains are larger than women's. But there is more to the story than that. Intelligence depends on much more than brain size. Such factors as an individual's body weight, age, and height should also be considered.

Suppose we could add body weights to the data above and calculate the fraction of each person's weight that was brain weight. The percentage ratio is calculated by dividing the brain weight by the body weight and rounding off to the third digit. (To save time, these calculations may be done on a calculator.) A table of brain weight/body weight ratios has been begun below. You must complete the calculations before proceeding to the exercise that follows.

Name ______________________________ Date ____________

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Men			Women		
Brain weight	Body weight	Brain weight/ body weight	Brain weight	Body weight	Brain weight/ body weight
1295	77180	.017	1194	59020	.020
1492	83990	.018	1131	60836	.019
1178	72640	.016	1077	69916	.015
1302	57650	______	1215	66284	______
1330	66500	______	965	63560	______
1485	78158	______	1289	65376	______
1347	67350	______	1429	69008	______
1412	74316	______	1083	49032	______
1391	73211	______	1233	70824	______
1268	60381	______	1139	62652	______
1438	63560	______	1217	67204	______
1313	72944	______	1212	53572	______
1150	74910	______	1017	61744	______
1253	68100	______	1391	71732	______
1322	55083	______	1049	46308	______
1280	58182	______	1105	52664	______
1222	81720	______	1169	49940	______
1230	72353	______	1334	55388	______
1157	52591	______	1176	59928	______
1240	65830	______	1274	72640	______
1118	69875	______	1339	67192	______
1185	51522	______	1203	54480	______
1310	65500	______	1386	58112	______
1530	61200	______	1150	51756	______
1062	59020	______	1290	50848	______
1208	63579	______	1181	45400	______
1380	88530	______	1248	64468	______
1372	120310	______	1059	68100	______
1277	106690	______	1320	56296	______
1453	66045	______	1125	48124	______

Name ______________________ Date __________

Study Skill 6, page 4

Making a Histogram Using the brain weight/body weight ratios data, make up two histograms, one for the data on men, the other for the data on women. (A separate page is provided at the end for drawing the histograms and the combined graph.)

The first step is to determine ranges of the ratios. In the table below, the range is two whole numbers, starting at .0095. Complete the table by filling in the ranges (to 0.255) and the midpoints of each range. Next, count the number of men and women with ratios that fall within each range. (The number of each should total 30.)

In constructing the histograms let the vertical axis represent numbers of individuals and the horizontal axis the ranges of brain weight/body weight ratios. (You may want to refer to the histograms included elsewhere in this study skill.)

Range of brain weight/ body weight ratios	*Midpoint*	*Number of men*	*Number of women*
.0095–.0115	.0105	1	0
.0115–.0135	.0125	1	0
.0135–.0155	.0145	2	2
.0155–.0175	.0165	5	3
.0175–.0195	.0185	______	______
______	______	______	______
______	______	______	______
______	______	______	______
		______	______
	Total:	______	______

After constructing histograms for men and women, draw line graphs on the histograms by connecting the midpoints of the bars.

Finally, combine the two line graphs in a separate graph, using a different color for each line. What conclusion about differences between men and women in brain weight/body weight ratios can be determined from the combined line graphs? Explain your answer.

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Name ______________________________ Date ______________

Study Skill 6, page 5

Name ______________________________ Date ____________

Study Skill 7
Using Models in Biology

Imagine that you are responsible for the health and welfare of a population of 200 persons who have found a pleasant planet on which to settle after surviving a long trip through space. Also imagine that the population consists of 100 women who are genetically AA and 100 men who are A^1A^1. How can you predict what the population will be like after a few generations? (Assume that mating is entirely random and that the alleles do not differ in their effects on viability and fertility.)

In order to work out this problem you do not need to study a real population. You can use a *model*, in this case a game, to make predictions. A model is a hypothetical description or analogy used to explain or predict a real-life phenomenon. A model simulates reality and is often used to minimize the penalties for error in real life.

By building models, scientists can reduce an object, a system, or a theory to manageable form. They can look at how the model behaves, play with it, and then make predictions about how the real object, system, or theory will work.

Models come in many forms. Sometimes they are in the form of computer simulations, charts, maps, or relief models and even include living systems. For example, biologists look at the behavior and physiology of animals to make predictions about human beings. Newly developed drugs, vaccines, and food additives are regularly tested on animals before being allowed to be sold to people.

A Random Mating Model Returning to the situation described in the opening paragraph, a model can be used to predict the outcome of random mating in this population.

Work with a partner and get two jars and some poker chips or other markers. You will need 100 chips of one color and 100 chips of another color. For example, let's say one color is red and R will represent the A gene. The other color is white and W will represent the A^1 gene. Put the red chips in jar 1 (the "eggs"), and the white chips in jar 2 (the "sperm"). If random mating takes place in the population how many of the offspring will be RR, RW, and WW? Write your prediction here:

RR ________ RW ________ WW ________

To determine the results of random mating, model 100 matings by removing one "egg" and one "sperm" for each mating. Note the colors of each pair and put a tally mark in one of the three columns for generation 1 on the tally sheet:

Tally Sheet 1

Generation	*Number of "Offspring"* RR	RW	WW
1			
2			
3			
4			

Now put half the chips into jar 1 to represent the eggs produced by generation 1, and the other half into jar 2 to represent the sperm. Repeat the modeling of mating as before and record the results for generation 2. Repeat twice more.

1. What have you learned about populations where mating is random?

An Epidemic Model Next, assume that after generation 4, an epidemic spreads through the population, an epidemic that attacks WW especially. What do you think the effect will be? Count the number of white (WW) "offspring" and remove 10 percent of them before putting the chips into the jars.

2. What do you think the effect will be?

Model the mating and record it as generation 1:

Tally Sheet 2

Generation	*Number of "Offspring"* RR	RW	WW
1			
2			
3			
4			

Again, remove 10 percent of the WW individuals. Repeat for several more generations.

3. What has this model shown?

Modeling a Small Sample Finally, assume that part of the generation 4 population was trapped on a remote part of the planet by a landslide. They survived and continued to reproduce for a few generations.

4. Do you think the proportions of alleles in the small population will stay the same?

To model this, put 10 red chips in jar 1 and 10 white chips in jar 2. Repeat the steps you followed for the random mating model and record the results:

Tally Sheet 3

Generation	*Number of "Offspring"* RR	RW	WW
1			
2			
3			
4			

5. What does this model show?

Name ______________________________ Date ____________

Mathematical Models A mathematical model can be used to predict what will happen to a natural population. For example, the original population of colonists consisted of 100 RR females and 100 WW males. Expressed as proportions, the eggs were 100 percent (or 1.0) R and the sperm were 100 percent (or 1.0) W.

When mating took place, this was the result:

Proportions of "Offspring"

		eggs 1.0 R	eggs 0.0 W
sperm	0.0 R	RR	RW
	1.0 W	1.0 RW	WW

Hardy-Weinberg Law Another way to represent the cross between RR and WW is in terms of the proportions of genes, without regard to whether they are in eggs or sperm:

Let P = the frequency of gene R;

Q = the frequency of gene W

So that $(P + Q)^2$ = the expected frequencies of different types of offspring.

So: P = .5 and Q = .5 (.5 = proportion of chips of one color)

Therefore:

$$\begin{aligned}(P + Q)^2 &= P^2 + 2PQ + Q^2 \\ &= (.5)^2 + 2\,(.5)(.5) + (.5)^2 \\ &= .25 + .50 + .25 \\ &= .25\text{ RR} + .50\text{ RW} + .25\text{ WW}\end{aligned}$$

Suppose that P = .09 and Q = 0.1.

$$\begin{aligned}\text{Then } (P + Q)^2 &= (0.9)^2 + 2(0.9)(0.1) + (0.1)^2 \\ &= 0.81 + 0.18 + 0.01 \\ &= .81\text{ RR} \quad .18\text{ RW} \quad .01\text{ WW}\end{aligned}$$

The formula above is used to demonstrate the Hardy-Weinberg law, which states in an algebraic form or mathematical model that a panmictic (random-mating) population tends to attain and maintain genetic equilibrium with regard to a pair of alleles in one generation and thereafter.

6. Do you agree with this model, based on your earlier model?

____

____

____

____

____

____

Name ______________________________ Date ______________

Study Skill 8

Testing a Statistical Hypothesis

Imagine that you are a research biologist who has been working for a long time to find a cure for the common cold. Today you are very excited because you think you may have stumbled upon the wonder drug that everyone has been waiting for. You have already done the preliminary testing to ensure its safety when used by human beings, and now you want to see how effective it is in curing colds.

To see whether the drug actually makes a difference, you will have to test it on an experimental group of people and compare the results with what happens to a control group, a group of people who will not receive the drug. Your experimental design will look like this:

Group	*Size*	*Treatment*
Control (Group C)	100 persons	Infected with cold virus
Experimental (Group E)	100 persons	Infected with cold virus, then given new drug

Suppose that after carrying out that experiment, you find that the average, or mean, recovery time for the control group is 7.10 days, and for the experimental group is 6.65 days. That isn't enough of a difference for your pharmaceutical company to be interested in marketing the drug. As part of your research you want to find out whether the drug really does make a difference, or if the difference is just a matter of chance.

Determining Deviations from the Mean

First you need to know more about how much variation in recovery time there is among individuals in the group. For example, a person in Group E might have recovered in 4.0 days. That value would differ, or *deviate*, from the mean value for Group E by −2.65 days. Another person might have recovered in 9 days. That would deviate from the mean by +2.35 days. The deviation for each individual can be determined in this way.

You need to determine the average for the entire group, but if you added up all the individual deviations, the sum would be 0. This is so because, by definition of mean, the individuals are equally distributed on each side of the mean. To get around that problem, square each deviation to get a positive number; then add all the squared numbers and divide the sum by the number of individuals. The formula for this is:

$$\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}, \text{ where}$$

$\sum$ = sum

x_i = individual recovery time

$\bar{x}$ = group mean recovery time

n = number of individuals in group

But this isn't quite what you were looking for. Since each deviation was squared, you must take the square root of the above formula:

$$\sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}$$

$$= s \cong \sigma = \text{standard deviation}$$

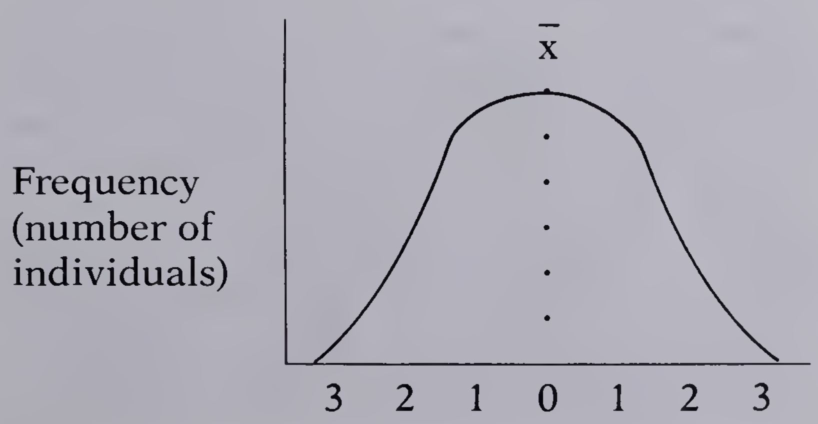
Incidentally, $\dfrac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}$ represents the

variance, σ^2, which is sometimes more convenient to use than the standard deviation. In this case, you find out that the standard deviation for Group E is 1.1 days, and the standard deviation for Group C. is 1.4 days. This means that the recovery time for the typical person in Group E is 1.1 days shorter or longer than the average for the group, and in Group C, 1.4 days shorter or longer. There is evidently some overlapping between Groups C and E, because a person from C who recovers 1.4 days before the C average will have recovered faster than a person from E who is 1.1 days over Group E's average.

Posing a Null Hypothesis The next step is to pose what is called a *null hypothesis*—the hypothesis that the result was merely due to chance. Scientists attempt to validate their findings by proving the null hypothesis false beyond a very small doubt. (The same principle is used in our system of justice, where a person is presumed innocent until innocence—the null hypothesis—can be rejected "beyond a reasonable doubt.")

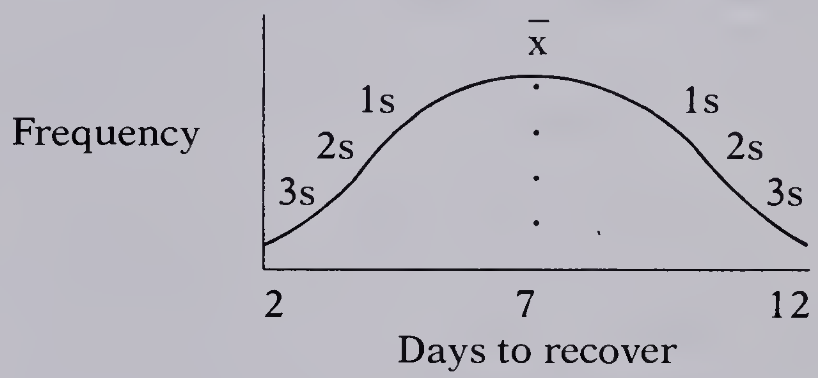
In this case, the null hypothesis would be that the apparent difference in recovery time is due to happenstance. An *alternative hypothesis* accounts for rejection of the null hypothesis. The alternative hypothesis states that the null hypothesis is false. In this case, the alternative hypothesis could state that indeed the drug has made a difference.

The null hypothesis is based on the variation within a typical population, in this case the population of which Group C is a representative sample. For many characteristics in populations, variation can be shown like this:



Notice that the x-axis is marked off in standard deviations from the mean and that the curve is bell-shaped. (In practice, few samples are exactly bell-shaped. The "ideal" population, however, would be distributed around the mean in this way.)

The characteristic being recorded in the control group (Group C) is the number of days needed by individuals to recover from a cold.



The number of days is shown on the x-axis. The standard deviations are marked off, based on the standard deviation of 1.4 days for Group C. Thus, one σ less than the mean is 5.7, and two less is 4.3. Similarly, one σ more than the mean is 8.5 days, and two more is 9.9.

Calculating the Z-score What you need to know next is whether the mean recovery time, $\bar{x}$, of the experimental group is reduced enough that there is only a very small chance—say less than two chances in a hundred, or 0.02—that variation in the population could account for this result.

To compare the means of two large samples like yours and find the probability that the difference in the means is due to this variation, you must calculate the Z-score. The Z-score is a standardized score that expresses the difference between the means of two independent groups with respect to the standard deviation of this difference. This deviation is not the same as the one you saw earlier. It is the standard deviation that would occur if you took many samples (instead of one) from each group and calculated the mean each time.

The Z-score shows you by how many standard deviations the mean recovery time

Name ______________________________ Date ______________

Study Skill 8, page 3

of Group E differs from the mean of Group C. A Z-score of 0 would indicate that the experimental mean equals the control mean; a Z-score of 1 shows the experimental mean to be one standard deviation to the right of the control mean, and a Z-score of −1 represents one standard deviation to the left. Once Z has been found, you can use the Z Table below to find the probability that the difference in means is due to chance alone.

Here is the formula for calculating Z:

$$Z = \frac{\bar{x}_e - \bar{x}_c}{\sqrt{\dfrac{s_e^2}{n_e} + \dfrac{s_c^2}{n_c}}}, \text{ where}$$

$\bar{x}_e$ = mean of Group E
$\bar{x}_c$ = mean of Group C
s_e = standard deviation of Group E
s_c = standard deviation of Group C
n_e = number of persons in Group E
n_c = number of persons in Group C

Using the numbers you have obtained for your experimental and control groups, calculate the Z-score. Use a calculator if you wish.

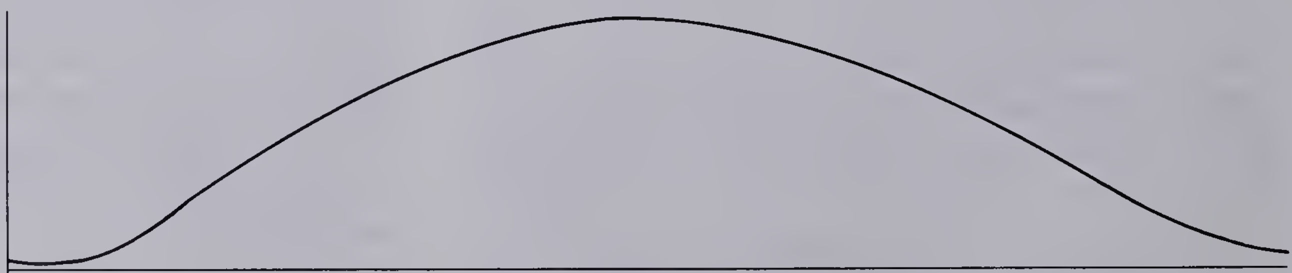
After calculating the Z-score, find the corresponding probability from the preceding graph. A Z-score of about −1.645 corresponds with a probability of 0.05 (5 percent) that the score is due to chance alone. This means that there is a 95 percent chance that the drug is effective in speeding recovery. At the 5 percent level 95 percent of the persons in the control group took longer to recover than the average person in the experimental group. The 0.05 figure is generally considered the benchmark, above which the null hypothesis cannot with assurance be rejected. Of course, if Z is +1.645, then the drug, to a confidence level of 95%, would actually be slowing recovery. The null hypothesis would still be rejected, but so would the drug!

1. What number did you obtain for the Z-score? ______________
2. How many standard deviations from the control mean is that? ______________
3. According to these results, the probability that this Z-score was obtained by chance is less than ________ and greater than ________ .
4. What does this probability indicate?

____

Z Table

Frequency (number of individuals



Number of standard deviations from mean	3	2.5	2	1.5	−1	0.5	0	0.5	1	1.5	2	2.5	3
Z-score	−3	−2.5	−2	−1.5	−1	−0.5	0	+0.5	+1	+1.5	+2	+2.5	+3
Proportion of individuals to the right	.999	.994	.98	.94	.84	.69	.50	.31	.16	.06	.02	.006	.001
Probability that the Z-score was obtained by chance	.001	.006	.02	.06	.16	.31	.5	.31	.16	.06	.12	.006	.001

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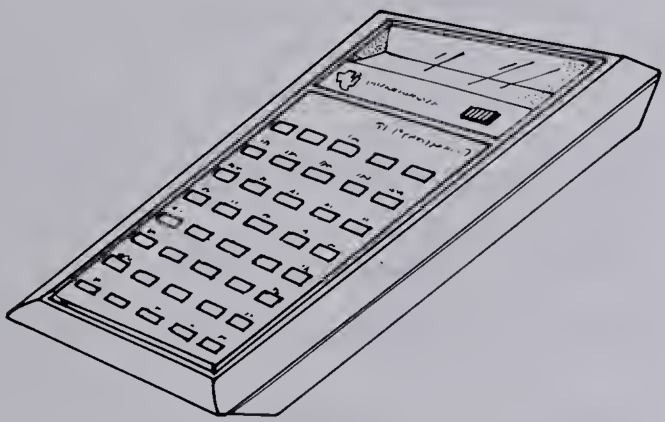
Study Skill 9
Using Calculators to Interpret Data



You have just gathered data from a research project. From your experience with statistics, you know that you must work through a series of equations to reach a value that will help you interpret the data and make inferences.

How do you work through the mathematics? Fortunately, time-consuming, longhand calculations are no longer necessary. The availability of inexpensive calculators lets us manipulate data quickly and efficiently.

Using calculating machines is not a substitute for understanding concepts, however. You still need to know *how* to find the square root of a number and what the *significance* of the value is in order to use it intelligently. Once you understand these concepts, you can use calculators to save time and leave your mind free to plan, develop, analyze, and make predictions.

Calculating Death Rates in a Stationary Population A stationary population model explains the dynamics of a group of people in a closed population that are born at the same moment and are followed through successive ages until they die. A closed population loses no members by emigration nor receives new ones by immigration. Such a population has A members present on average during one particular year and D deaths which occurred during that same year. The proportion of deaths to survivors can be expressed as M (mortality, or death rate) = D/A.

Let us say that in the fictitious country of Zeus, in 1964, the midyear population was estimated at A = 191 372 000 and registered deaths were estimated at D = 1 798 051. If M = D/A, then what is the value of M? (M = 0.00940 or 9.40/thousand) M = D/A is the equation used to calculate the *crude death rate*. It is *crude* because it does not distinguish between mortality and age distribution.

A more meaningful formula deals with a homogeneous group consisting of a population containing members of one age and one sex. Let males from age x to (x + 1) (in other words, the group aged x at the last birthday) number K_x at the middle of the calendar year, and the deaths among them over the calendar year number D_x. The *age-specific* death rate for males at age x is then calculated as $M_x = D_x/K_x$.

If, in July 1964 there were 1 081 000 men aged 32, and if 2317 men of this age died in 1964, what was the age-specific death rate?

$$(M_{32} = \frac{D_{32}}{K_{32}} = \frac{2317}{1\ 081\ 000} = 0.002143 \text{ or } 2.143/1000)$$

Using Your Calculator's Memory In this exercise you are asked to complete the calculations begun in the table below, titled "Age-specific Death Rate for Males in Zeus." Data is provided in order to calculate the age-specific death rate and the male population of Zeus for each year over a ten year period. Using your calculator, you will determine the value of K_x and M_x for each year and enter the results in the appropriate column.

The memory function of your calculator will enable you to do the work easily. The instructions below are written for the TI-55 calculator; if your calculator is a different type, you may have to consult your handbook and modify the instructions.

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To calculate $M_x = D_x/K_x$:

Enter	*Press Keys*		*Display*	*Comments*
	2nd	CA	0	Clears memory
1 081 000	STO	1	1 081 000	Stores number in memory 1
	–			
2317	STO	2	2317	Stores number in memory 2
	=			
	STO	4	1 078 683	New population number (K_x), (Record this.) Stores number in memory 4
	RCL	2	2317	Recalls number of deaths
	RCL	1	1 081 000	Recalls old population number
	=		.0021434	Gives value of M_x (Record this.)
	RCL	4	1 078 683	Recalls new population number. Continue as above.

After reviewing the steps above, go ahead and perform the calculations for K_x and M_x using your calculator. Record your calculations in the table that follows.

Table 1. Age-specific Death Rate for Males in Zeus

Year	*Age*	*D_x = number of male deaths*	*K_x = Population of males (mid-year value)*	*Value of M_x*
1964	32	2317	1 081 000	.002143
1965	33	2479	1 078 683	______
1966	34	2986	______	______
1967	35	2845	______	______
1968	36	1945	______	______
1969	37	1854	______	______
1970	38	1501	______	______
1971	39	1499	______	______
1972	40	1302	______	______
1973	41	1285	______	______
1974	42	1233	______	______

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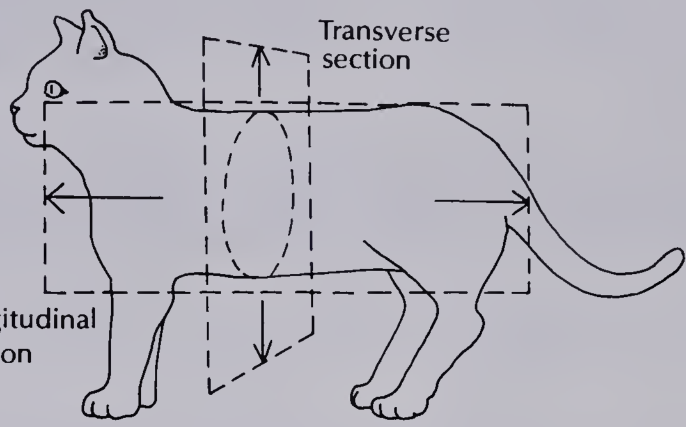
Study Skill 10
Seeing in Three Dimensions

In this study skill you will learn to visualize the planes of dissection of a bilaterally symmetrical animal. An animal that is bilaterally symmetrical can be divided lengthwise into left and right halves that are alike, each being a mirror image of the other. All vertebrates, including humans, fit into this category.

Biologists use terms referring to planes of dissection, or sections, to describe the positions of organs in a body. Though it may seem awkward at first, using these terms makes it much easier to describe and locate precisely the parts of the anatomy of biological specimens. In effect, a specimen is able to be viewed mentally in three dimensions.

The terms introduced here are from the *Nomina Anatomica Veterinaria*, an international index to the anatomy of animals. It includes the standard terms used to describe locations of structures in quadrupeds, animals having four feet.

Sectioning a Specimen The Greek word *anatomia* means "to cut up." A specimen is cut into various sections to reveal the location of internal organs. The cuts may be made vertically along the length of the specimen on a longitudinal plane or across the body on a transverse plane at right angles to the longitudinal plane:



A vertical, **longitudinal** section or cut is also referred to as a sagittal section. The term *sagittal* is from the Latin word which means "arrow." In using the term *sagittal* it may help to visualize an arrow splitting apart an object which it hits, dividing it into left and right halves. A **transverse** section, or cut across the transverse plane is also known as a cross section.

Terms Indicating Direction In describing the location of parts of the body or of organs within a section, terms are used that refer to the front end or back end and the upper or lower surfaces of the specimen. Several commonly used directional terms are given below:

- **anterior** (or **frontal**): toward the head or front end
- **posterior** (or **caudal**): toward the hind or tail end
- **dorsal**: in the upper or back area
- **ventral**: in the lower or belly area
- **lateral**: on the sides, on either side of a vertical longitudinal section
- **mid-** (or **medial**): along or toward the middle
- **proximal**: nearest the point of reference (such as the head or the stomach region)
- **distal**: farthest from the point of reference

Name ______________________________ Date ____________

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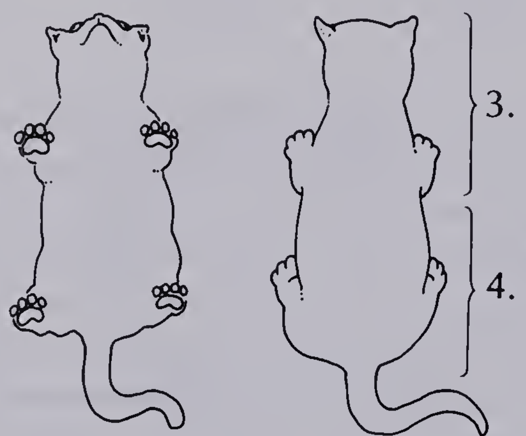
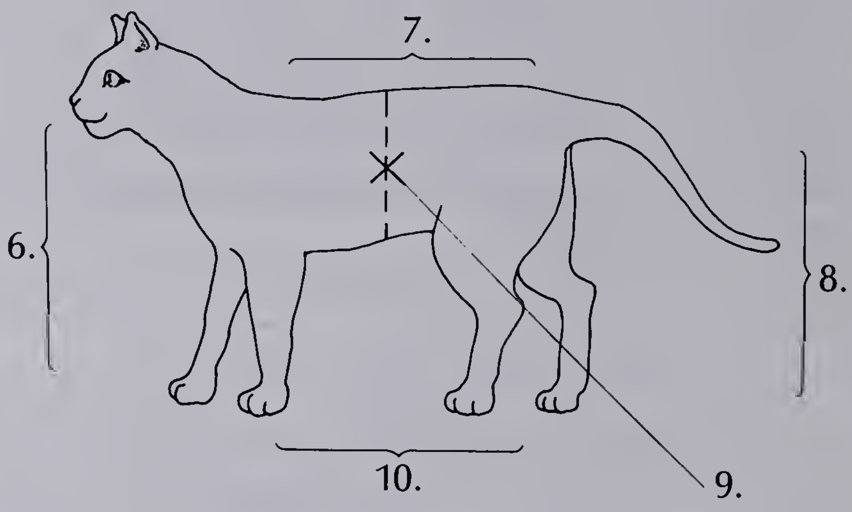
These terms may be used to describe sections as well as to indicate direction, such as *dorsoventral cross section*, which describes a transverse section that passes from back to belly. A *midsagittal* section passes through the middle of the specimen longitudinally and separates the body into left and right halves.

Applying the Terms Once you feel that you understand the terms explained above, proceed to the skill exercise that follows. Each of the drawings of a cat illustrates an aspect of viewing the specimen that can be described in terms of direction or sections. The answer blanks below each drawing correspond to the numbered leaders pointing to various parts of the drawing. In some cases you are asked to identify the correct directional term; in other cases the section must be identified. Use only those terms introduced in this study skill.

Directional Terms:



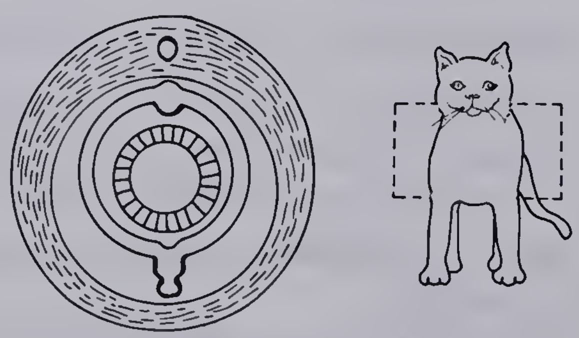
1. ______ view. 2. ______ view.



5. ______ view.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

Sections:



11. ______________________________

or ______________________________

12. ______________________________

or ______________________________

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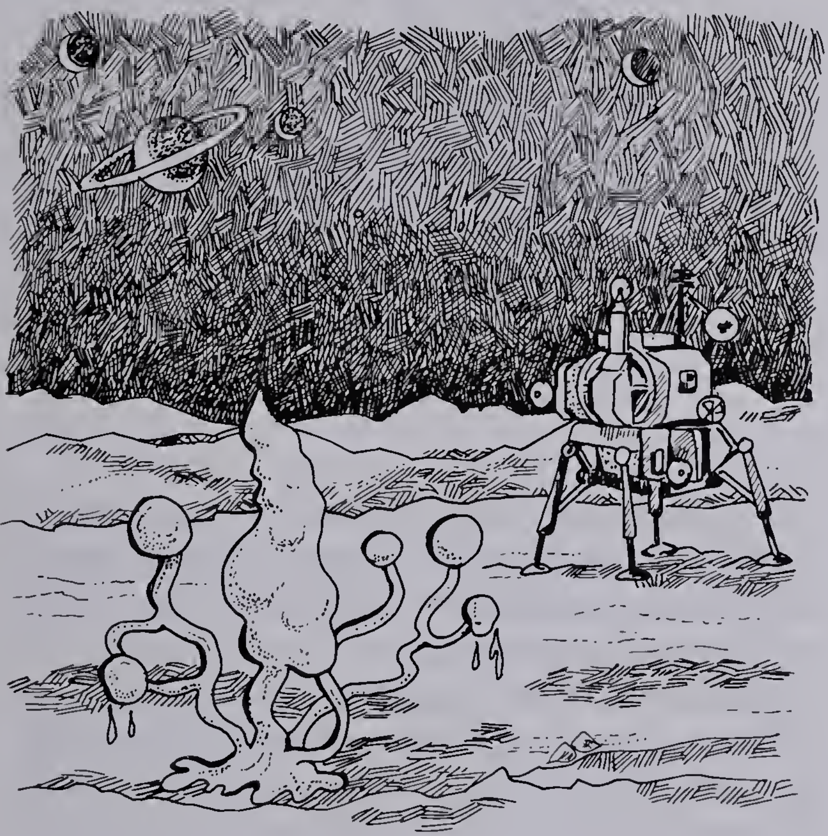
Study Skill 11
Illustrating Biology with Drawings



Imagine that you are on a scientific expedition in a spacecraft. You and your crew stumble upon a planet not yet recorded. You decide to take a scouting party to explore the planet's surface, where you discover the most wonderful plant life imaginable. In the interests of science, you immediately begin to record your findings in order to communicate to your colleagues on earth what you have seen.

What is the most effective way of doing this? You could use your best prose or poetry to try to evoke the images of the strange, unclassified plants, but your description might lack the accuracy and integrity so necessary to any kind of scientific communication.

You could take photographs, but the results are two-dimensional and you would have to wait for the negatives to be developed before being able to describe in words what is in the photographs.

An efficient and a more accurate way to record what you have seen is to supplement your word description of the specimens with drawings.

In this exercise, you will make drawings of a fairly simple biological specimen. You do not have to be an artist to put down an accurate, clear rendition of a specimen. The most important thing is to provide enough detail to make the drawing understandable.

Materials Choose a comfortable chair and, if possible, a drawing board you can tilt slightly or a clipboard. You may use any type of board as long as the surface is hard, smooth, and clean. If you don't have a board available, work at a table or desk with a smooth surface. The direction of the light should be from the left (or from the right for left-handed people) so that your hand does not cast a shadow over the space where you are drawing.

For basic drawing, you will need some medium-hard pencils: HB or No. 3. The paper should be fairly transparent so that the drawing can be revised in stages on several overlays. You will also need an art-gum eraser.

The Drawing First, find a specimen to draw. It is easiest to begin with a stationary object such as a shell, a leaf, or a bone. Become well-acquainted with your specimen. Pick it up, turn it around, look at it, feel its shape and texture, notice the patterns and the sizes of different parts.

Next, close your eyes, and as you feel it, let a picture of the specimen grow in your mind. Then, open your eyes and squint at it. Squinting gives an abstracted idea of the specimen since detail is absent and you can see basic pattern outlines. (As you draw, squint at the subject occasionally to remind you of its abstract qualities.)

The art of drawing is the ability to produce an integrated illustration, where all

Name ______________________ Date __________

Study Skill 11, page 2

the parts contribute to a general impression. Look at your specimen and identify the patterns of growth: the curves, rhythms, symmetries, asymmetries, and so on. As you discover the inherent order in the colors, shapes, and textures you will be more able to represent them accurately.

Now you must make a decision about which aspect of the specimen you will represent in the drawing. If you want to communicate specific information, draw the subject in a straightforward manner and from a common angle, such as head-on or in profile. After deciding how to position it, fix the specimen in place on the board or desk with wet, crumpled paper towels or plastic clay.

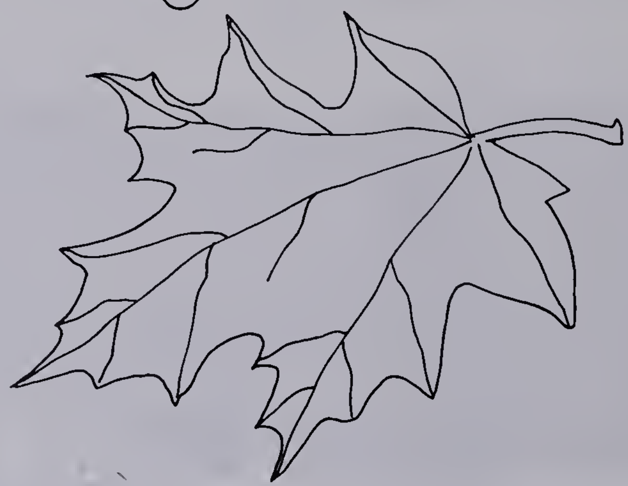
Next, decide what size the drawing will be. The greater the detail you wish to include, the larger you will want the drawing to be. If the subject is very simple and large, you may want to reduce the size of the drawing.

If possible, begin by drawing to the same size and measure your subject one-to-one. Measure the width and the height of the specimen and lightly draw a rectangle using the same measurements. The outline of the specimen should touch the measured rectangular outline on all four sides. All further measurements are made in relation to the outline of the rectangle. To enlarge or reduce the size of the subject in a drawing you would need to determine a scale, such as 2 to 1, or 3 to 4, and adjust the measurements to that scale.

Lines should be drawn lightly at the beginning so you can revise them as you glance quickly from specimen to drawing. Don't try to make an artistic or idealized drawing. Draw exactly what you see, not what you imagine should be there.

Putting Pencil to Paper As you make several drawings of your specimen you will be able to experiment with portraying texture and contour.

Make five outline drawings like the example below.



The next things to consider in your drawings are color, texture, and contour. Shape or contour should be dealt with first since the details will be built on the basic form.

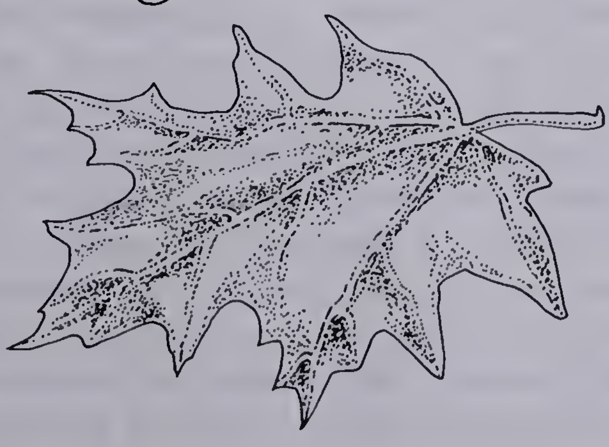
Next, carefully study the texture. Is it shiny, rough, smooth, grooved, wet, serrated, soft, dull? Often texture is a combination of these different types. You may notice texture patterns that remind you of geometrical shapes.

Now, look closely at the color. Think of color as a gray value painted on the surface. Various shades of gray and white should follow the contour and texture of the subject.

Make six drawings of your subject in different positions. Examples are given in the following figures. Try to capture light areas, shadows, depth, and so on by using line shading.

As a beginning exercise, redraw with tracing paper the example provided; this allows you to get a feel for how the artist drew the lines. Then, try making a drawing of your own. If you have difficulties interpreting the texture of your subject into lines, try putting tracing paper over your outline drawing and experiment with different line forms and thicknesses.

Stippling In addition to the line drawings, make at least two stipple drawings of your subject. Stippling is a drawing technique that uses dots rather than lines to show contour, depth, and texture. (See the examples below.) Although stippling is slower than line drawing, fewer mistakes are made and the resulting drawing is usually quite acceptable.



For stippling work, choose a pen with a stiff point, such as a quill pen or mechanical pen. First, practice drawing a contour surface outline by placing dots at an equal distance from each other to trace the outline. Next, vary the density of dots within the drawing to produce shading effects of depth, and light and dark areas. Find other examples of stipple drawings and study how this technique is used to show texture, depth, and contour. Usually the dots do not touch each other but seem to be placed at random on the paper.

After completing all your drawings, show them to another student for comments. Discuss how you can improve your drawing technique to represent the subject more accurately or in more detail. After some practice with drawing biological subjects you will find that your skills in observing detail have improved along with drawing skills.

Name ________________________________ Date ____________

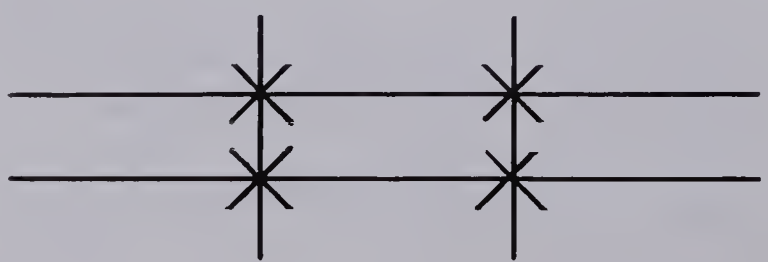
Study Skill 12
Illustrating Biology with Photographs

Photography is an excellent way to tell a story or illustrate a research paper. A well-planned series of pictures can save hundreds of words of explanation. The discussion that follows presents helpful hints and a series of steps to take to make your photo story more effective.

Plan for Content Decide first what you wish to convey in photographs. Use index cards to plan and organize photo subjects. This might include a rough sketch to show what the picture should include. Supplement the sketches with relevant background data. For example, if you want to show movement in a plant, you might want to include some specific details about turgor changes and phototropism.

Composition To enhance the impact of your photographs, select and arrange the subject carefully within the picture area.

Have one strong center of interest. If you want to include a secondary subject, be sure that it doesn't detract from the main subject. Avoid putting the center of interest in the middle of the picture, as this kind of composition can look static. Try placing the subject according to the rule of thirds. Divide the picture area into thirds, both vertically and horizontally and place your main subject at one of the four places where the lines intersect, as indicated by the Xs.



When you have found your subject, such as a spider web, study it from *all* angles and then select the view that shows the subject to best advantage.

Looking through the viewfinder, move toward your subject until you have cut off everything that does not add to the result you wish. Though it is possible to crop the picture later, composition is more effective if you eliminate unnecessary elements before snapping the shutter.

Lighting If you are taking pictures outdoors, you will usually want your back to the sun with the subject in front of you. This is called frontlighting, because the light falls directly onto the subject. The result will usually be a well-exposed picture full of detail.

If the sun is on your right or left, shadows will show up on half of the subject. Such sidelighting can be effective if you want to emphasize texture, such as foliage in the setting sun or rock formations. If the light is behind the subject, the result will not show much detail. However, backlighting can provide a dramatic silhouette or halo effect. This is more easily done in the early morning or late afternoon, when the sun is low.

Film Speed Chemically, film is a light-sensitive emulsion on a plastic base. The emulsion is made of silver halide crystals. When light strikes them, a chemical reaction takes place, and the image of what the camera has seen is preserved. Black and white film has one layer of emulsion; color film has several layers, each layer recording a different color.

There are different "speeds" of film available. Speed refers to the time it takes for reactions to take place in the emulsion layers. You may have already used ASA 100 or ASA 64 (ASA indicates film speed).

Many amateur photographers use ASA 100 film as a general rule because good results are possible even if moderate exposure errors are made. It can be used with flash attachments, in daylight, or even indoors if it is not too dark. A rule of thumb is: the

higher the film speed, the greater the film sensitivity to light, and the more grainy the picture will be, especially if enlarged.

ASA 64 is a slower film that requires more lighting and less movement of the subject. However, the resulting pictures are very sharp, less grainy, and have excellent color and great detail. ASA 400 film is a high-speed film for taking pictures in dim lighting without a flash, or of subjects moving very fast. ASA 200 film is a good compromise between the ASA 100 and ASA 400 if you are not sure of your lighting conditions and want sharper details than you would get with ASA 400.

Your choice of film should be considered in the beginning of your planning and noted on your index cards.

Additional Pointers

- Read the manual that comes with your camera. It contains invaluable information about taking advantage of the features of your camera to achieve the best results.
- Always hold the camera steady and squeeze the shutter smoothly.
- Always be sure that the horizon is level and not tilted.
- Fill the frame with your subject.
- Be creative. If you are taking pictures of a spiderweb, for example, a fine spray of water with sidelighting can produce a striking effect and still provide the information you want to convey.
- Keep records as you take your pictures. Record the date, subject, frame number, and any pertinent information regarding lighting or special effects. When your pictures have been developed, you will be able to use the information in your notebook to evaluate the effectiveness of your techniques.

Photography Exercise Using the outline provided below, plan a series of photographs to illustrate a biological subject or phenomenon (such as color variations in a species of insect, or a series that illustrates field to forest succession).

This exercise is in two parts. In the first part you will plan the photos, filling out an index card for each subject, or series. The second part involves recording in a notebook data on where, when, and how the photos were taken. After the film is developed, you will want to identify each print or slide and then make comments as to the quality of the photographs and how they might be improved.

Photography Exercise

Planning

1. Goal(s) and/or effects desired:
2. Rough sketch of subject:
3. Relevant data necessary for idea to be conveyed successfully:

Recording

1. Location, date, and time of day: (You may also want to include weather conditions.) ____________
2. Technical information (Record this even if your camera is automatic):
   a) Film speed (ASA#): ____________
   b) Lens type (28 mm, 50 mm, etc.): ____________
   c) Filter type (if any): ____________
   d) Aperture number (F stop numbers that indicate opening size of the diaphragm): ____________
   e) Shutter speed: ____________
3. Identify developed photos.
4. Comments: (Are you happy with the finished product? Why/Why not? What would you do differently next time? Why?) ____________

Essay 2
The Unhealthy Heart

In 1911 Russian scientist Dr. Nikoai Anitschkov examined the arteries of people who had died of heart attacks. Many of the arteries were clogged with deposits of a fatty substance called cholesterol. He concluded that the deposits were the result of eating foods containing cholesterol. Later researchers had similar results. Thus began the cholesterol scare, which has led many people to give up their morning eggs in the hope of preventing heart troubles.

Fat Theories Many scientists blame cholesterol as the villain in heart disease. Cholesterol, which belongs to the group of lipids known as saturated fats, is found in every human cell. The body manufactures most of its cholesterol, and takes in more in high-cholesterol foods like dairy products and many meats.

Some studies indicate that a diet high in cholesterol increases its level in the blood. This accumulates as fatty deposits in the arteries and restricts the flow of blood to the heart.

Advertisers have capitalized on such reports by promoting foods like "Egg Beaters," a cholesterol-free alternative to eggs. Eating foods with little or no cholesterol, they imply, helps prevent heart disease.

The cholesterol theory is challenged by other studies. One compares Trappist monks, who followed a vegetarian low-fat diet, and Benedictine monks who ate meat and dairy products. The incidence of heart disease was the same in both groups. In certain poor countries, whose people eat a great amount of high-cholesterol foods like pork fat, the death rate from heart disease is quite low.

As of yet, no one has conclusively proved that cholesterol alone contributes to heart disease. Nor is there conclusive evidence that eating less cholesterol will reduce the likelihood of heart problems.

While the cholesterol controversy rages, some scientists are looking at the level of triglycerides in the blood as a cause. Triglycerides are neutral fats, normal components of blood. The triglyceride level is difficult to control by changing the diet. A person would have to completely eliminate fat intake to remove triglycerides from the blood, which would be hazardous because fat intake is essential for many physiological functions.

Exercise for Health Some studies have implied that regular vigorous exercise can benefit the heart. The National Aeronautics and Space Administration (NASA) found that an exercise program can result in lowered resting heart rate, lowered blood pressure, increased stamina, reduced weight, and lowered stress levels. A supporting study at the Cardiopulmonary Research Institute in Seattle found that the mortality rate in heart patients not involved in a supervised exercise program was double that of patients who did exercise.

Other research points to opposing conclusions. Methodist Hospital in Houston did a 5-year study of men who were runners, aged 40 to 60. During that time, a large proportion of them developed evidence of coronary heart disease.

Mutating Cells Still another theory was developed by Dr. Earl P. Benditt at the University of Washington School of Medicine. Benditt's experiments produced the "monoclonal-proliferation theory" of heart disease.

This theory states that arteries become diseased due to the presence in the bloodstream of chemicals such as pollutants, smoke components, and reactive molecular fragments called free radicals. These chemicals cause smooth arterial muscle cells to mutate, forming a benign tumor or plaque. The mutated cells produce exact replicas (hence the term *monoclonal*) and proliferate faster than normal cells. The plaque cells produce collagen and cholesterol, forming a fibrous mass. Eventually,

this mass erupts through the arterial wall into the bloodstream and attracts calcium and cholesterol by electrostatic charge attraction. The mass increases in size, reducing blood flow and increasing clotting.

Not all researchers agree with this theory. Benditt's colleague George Martin argues that the data do not prove that plaques are formed by mutated cells. Similarly, Wilbur Thomas at Albany Medical College found that plaques in swine are not monoclonal. Despite arguments against the monoclonal theory, no one has conclusively disproved it.

Total Protection Many doctors believe that the risk of heart attack is directly related to the combined physical and mental health of the individual. People who smoke, drink alcohol, are overweight, do not exercise, and eat large amounts of refined carbohydrates are more susceptible to coronary malfunction. These doctors recommend a balanced diet of protein from eggs, cheese, meat, milk and fish along with carbohydrates from whole grains, unpolished rice, and fresh fruits and vegetables. They also recommend keeping weight down and reducing fat intake to a healthy minimum.

There are many other research efforts that have tried to determine the causes of and preventive measures for coronary heart disease. Undoubtedly, the controversy will continue until conclusive evidence is found. But what do we do until then?

Questions for Discussion and Research

1. If evidence for a cause of heart disease is conflicting, should we change our habits? For example, should we lower our cholesterol intake, or exercise more?
2. Who should determine whether evidence is conclusive?
3. If cholesterol, smoking, drinking alcohol, or other factors are proved to cause heart disease, what should be done? Should cigarettes, alcohol, and high-cholesterol foods be banned or heavily taxed? Should smokers pay higher health insurance rates? Or, should people simply be educated about the dangers?

Essay 3
Seed Banks

In the late 1840s a disaster hit the small country of Ireland. A fungal disease called the potato blight ruined the entire crop of potatoes. About 30 percent of the Irish population died of starvation or disease, or fled the country.

The disaster can be traced to sixteenth-century English explorers who returned to Europe from the Caribbean with exotic plant species, including the potato. Unfortunately, they brought only one variety of the vegetable, which became the primary food source for the Irish. It was inevitable that, at some time, the plant would be struck by disease. If more than one variety of potato had been available, Irish history might have been entirely different.

Popular Plants Prehistoric peoples used over 1500 species of wild plants and cultivated about 500 vegetables. Because modern agriculture can produce crops in such abundance, it takes fewer varieties of plants to feed the industrialized world.

Today, about 95 percent of human nutrition comes from only 30 species of plants. The key 15 of these are rice, wheat, corn, sorghum, barley, sugar cane, sugar beets, potatoes, sweet potatoes, cassavas, common beans, soybeans, peanuts, coconuts, and bananas. One report showed that just three crops—wheat, rice, and corn—produce over 68 percent of the world's seed crop. Thus, millions of lives depend on the pests, diseases, and environments of just three crops.

Furthermore, fewer than 10 percent of the earth's 300 000 higher-order plants have been studied; fewer than 3000 of these have been studied in detail.

Plant Immigration Many of the species grown in the United States are not native plants. For example, of California's many cultivated crops, not one is native to the state. Only three of the major crops harvested in North America are natives: artichokes, cranberries, and sunflowers.

Where did these plant immigrants come from? The Russian scientist N. I. Vavilov studied the environments of many species: climates, cultivation method, soil, water supply, and land form. He concluded that almost all major crops originated in areas that make up less than one-fourth of the arable land on earth. These areas (called "Vavilov Centers") are the Mediterranean, the Near East, Malaysia-Java, China, Afghanistan, Indo-Burma, Guatemala-Mexico, the Peruvian Andes, and Ethiopia. Many of these areas are located in or around Third World nations.

Vavilov concluded that during the Ice Age plant species could thrive only in these areas, because they were tropical. Most of the temperate zones, now occupied by the more developed countries, were frozen. As a result, plant development in temperate areas was restricted.

The Third World Greenhouse The Third World is a source of many plant species for another reason. Farmers in Third World nations have been cultivating today's major food crops for over ten thousand years. Generations of farmers have cultivated many varieties of each species, so that flood, drought, or pests could not wipe out an entire crop.

Consequently, the Third World is rich in botanical genetic resources. The developed countries may have to depend on this greenhouse for new plant species.

Losing Species, Saving Species Some scientists are concerned that genetic resources throughout the world are being lost. There is pressure to convert farm land to grazing lands, old farming practices are being abandoned, and growing populations are demanding land for shops and houses. Because of these pressures, the genetic diversity necessary for plant improvement is being lost.

Many scientists feel that steps should be taken to increase the genetic variability of

gene pools. The major question is, how to preserve a variety of species?

Currently, there is a world genetic resource network. The International Board For Plant Genetic Resources (IBPGR) coordinates eight international crop research stations, which are all located in the Vavilov Centers.

There are sixty national gene banks in the world today. The National Seed Storage Laboratory (NSSL), located in the United States, is the world's storehouse for many major crops. It supports the seed banks and the IBPGR and its stations.

Many scientists agree that given proper financial support, these organizations could do much to preserve diverse species. However, because there is not sufficient support, they fear that valuable seeds will be lost, without the hope of ever replacing them.

Gene Banks The germ plasm of many valuable species is stored in the form of seeds in gene banks. However, the banks are vulnerable. Power failures, fires, floods, budget cuts, and changes in temperature or humidity can put whole collections in jeopardy. Many seeds are even lost during shipment to the storage facilities.

In addition to national and international government-supported banks, many large companies have substantial genetic collections of their own. Some scientists accuse them of hampering preservation efforts by refusing to share information with government banks. Also, there is fear that a private group that controls genetic resources could gain overwhelming political and economic power. The companies respond that since financial support is scarce for national gene banks, they are justified in protecting their invaluable collections.

Plant Zoos Not all scientists are convinced that gene banks will save disappearing plant species. One alternative is biosphere reserves, where plants would be grown in controlled environments. Areas in 35 countries have been designated as future reserves.

Some scientists call this plan unrealistic. The National Academy of Sciences has noted that the 35-year American effort to maintain germ plasm collections of fruits, nuts, and vegetables has not been successful. Furthermore, it states: "After weighing all available measures for preserving endangered species under controlled conditions, we are repeatedly forced to the conclusion that the only reliable method is in the natural environment."

Questions for Discussion and Research

1. Should gene banks be owned by governments, private organizations, or both?
2. Should agrichemical companies be allowed to develop plant varieties that will need their chemicals, and thus stimulate sales?
3. How can developed countries rise above political problems and cooperate with Third World nations to preserve genetic resources?
4. Who should control the Vavilov Centers?
5. What possible roles can individuals have in conserving plant genetic resources?

Essay 4
The Effects of Radiation on Life

In August 1945 atomic bombs were dropped on the Japanese cities of Hiroshima and Nagasaki, ending World War II. Years later, American and Japanese researchers tried to discover the long-term effects of radiation exposure on the 250 000 survivors. They estimated that 562 more people died of cancer than would have been normally expected.

In addition, studies showed that a radiation dose of 20 rads increased the incidence of leukemia in children. Doses from 50 to 100 rads caused increases in birth defects and growth retardation in those who were exposed as fetuses. (A "rad" is the measure of radiation absorbed by organisms; the average yearly dose for humans from background radiation is 0.2 rad.)

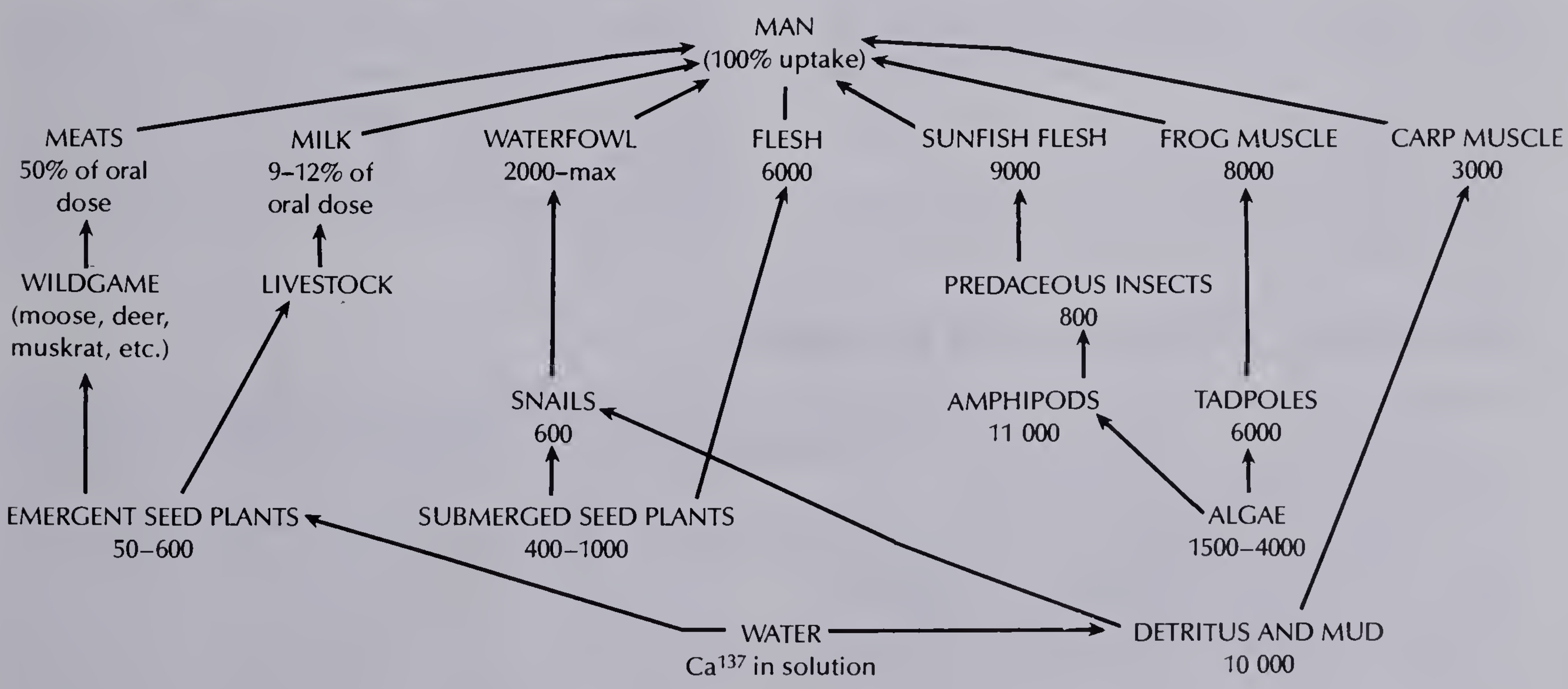
Other researchers have studied radiation effects on people who lived near nuclear test sites. Between 1951 and 1958, 26 atmospheric nuclear tests were conducted at a Nevada site. Children who lived downwind from it were, on the average, 2.4 times more likely to die from leukemia than children living in areas far away from test sites.

Because of these and other findings, scientists have taken a closer look at the effects of various kinds of radiation exposure.

Everyday Radiation Although few of us are exposed to large doses, none can escape minimal exposure to background radiation. Natural background ionizing radiation is composed mainly of cosmic rays, emissions from the decay of radioactive elements in the earth's crust, and emissions from radioactive isotopes occurring naturally in the body. Other sources of radiation are medical equipment, radioactive minerals in certain types of crushed rock, building materials, phosphate fertilizers, radiation-emitting components of television sets, and smoke detectors.

Some radiation reaches human beings indirectly. The diagram illustrates the complex pathway followed by the radioactive trace element cesium-137 from water to humans. Each plant and animal on the path concentrates the element to a different extent.

Radiation and the Body The possibility that cancers and genetic defects could result from small doses of radiation became a con-



Subtended number are concentration factors $\frac{Ca^{139} \text{ concentration in organism}}{Ca^{139} \text{ concentration in water}}$

Figure: Movement of Cesium-137 from Fresh Water to Humans (Pendleton & Hanson 1958)

troversial issue in the 1950s. E.B. Lewis of the California Institute of Technology inferred from studies of the frequency of leukemia in atomic bomb survivors that the incidence of cancer might increase as a result of mutation in a single cell. This interpretation implies that every dose of radiation *could* have some carcinogenic effect. This issue remains controversial today.

Although there is disagreement about dosage, threshold levels, and hereditary effects, scientists know that radiation can cause cancers and genetic defects. As low-level ionizing radiation penetrates living tissue, it collides with the atoms and molecules in cells. These collisions produce large numbers of ions and reactive radicals, which in turn change molecules around them.

These changes can cause lesions on DNA molecules, breakage and rearrangement of chromosome fibers, and interference with the normal segregation of chromosomes when the cell divides. Such mutations may be passed on to offspring.

The mutagenic action of radiation on genes has been studied extensively, but no hereditary effects have yet been seen in human beings. For example, no detectable increase in genetic abnormalities has appeared in the children of atomic-bomb survivors. However, effects have been shown in other species, especially mice, in which frequency of mutations increased in proportion to the radiation dose level.

Many scientists are critical of the inferences made from such studies because there is no convincing connection between specific incidences of cancer and radiation exposure. The difficulty is that radiation-induced cancers appear no different from cancers associated with cigarette smoke, drugs, pollutants, and other hazards. Also, cancers do not appear until years or decades after exposure to carcinogens.

Defining Risks In spite of the uncertainty, many people insist that any possible risks from radiation exposure should be considered. The controversy over risks has centered on radiation levels in and around nuclear power plants. Government and the nuclear industry formed committees to determine "permissible" radiation doses.

Pronuclear groups said that in the accident at the Three Mile Island nuclear plant in Pennsylvania, the average exposure to radiation to people nearby amounted to no more than that of a chest X-ray.

However, according to anti-nuclear groups, if the accident had exposed 1 million people to this "small" dose, 74 cancer fatalities could have resulted. It is a violation of fundamental human rights, they believe, to impose risks on individuals without their consent. They argue that no by-products of human activity, including radiation, should be allowed in the environment unless they are proved safe.

The estimation of health hazards due to exposure to low-level radiation is a scientific problem. Still, we must weigh the possible risks of exposing ourselves to sources of radiation against the benefits of nuclear power generation and other uses of radioactive materials.

Questions for Discussion and Research

1. We need energy. But how do we decide if the possible dangers of an energy technology (nuclear power, coal, oil, gas, or others) outweigh the known benefits? Are there any energy technologies that are risk-free?
2. In the face of uncertainty about safe levels and the effects of radiation, should radiation sources be controlled? If so, by whom?
3. What can individuals do about radiation risks?

Essay 5
The Genetic Frontier

Six-year-old Marsha was playing on a swing in her backyard. Suddenly, she fell and died of a heart attack. In Chicago, a baby was born with a cholesterol count of 900 on a scale where 80 is normal. Both these children had a genetic heart disease named familial hypercholesterolemia, or FH. Victims of FH have too high a level of blood cholesterol because of an error of fat metabolism. The high cholesterol level leads to atherosclerosis and eventually heart attacks.

As yet, there is no cure for genetic diseases like FH. More than 2000 ailments are known to be caused by a defective gene. Most are rare, but together they add up to 10 percent of all human diseases.

Genetic engineers hope that it will some day be possible to transplant a healthy gene into a potential victim to correct a disease-causing error. Genetic engineering is the technique of changing the gene combination on DNA.

Putting Genes to Work Genetic engineers are already helping to produce new drugs, such as insulin, human growth hormone, and interferon. With transplanted human genes, bacteria may be able to produce human-type proteins that could be used by human patients.

Genetic engineering also promises an exciting future for agriculture. New genes could be "spliced" (transplanted) into crops to enhance their nutritive value, make them disease- and insect-resistant, and make them more productive. Nitrogen-fixing bacteria could be inserted into plants, enabling them to make their own "fertilizer" by fixing nitrogen from the air. Livestock may also be improved by gene-splicing.

There are also proposals for engineering bacteria to scavenge metals from low-grade ores, break down pollutants in contaminated water, and extract residual oil from nearly depleted wells. We could make microbes that can clean up oil spills, or that produce protein from oil or even from garbage and industrial wastes. Large cultures of bacteria could become the high-technology factories of the future.

In 1981, a "gene machine" was put on the market. It can automatically synthesize fragments of any gene whose genetic code is typed onto its keyboard. The desktop gene machine does in one day what used to take scientists four to eight months to accomplish. It can make a synthetic version of a natural gene or a gene totally unknown in nature, which can be spliced into the DNA of a living cell. Assuming that the created genes would be passed from parents to offspring, new animal and plant species would be created.

Right or Wrong? Do we have the right to manipulate heredity in these ways? The process of natural selection is efficient, eliminating individuals with serious defects before they reproduce. However, advances in medicine save the lives of many people who would otherwise have died from genetic defects. If these individuals reproduce, their defects remain in the gene pool. At the same time, we are exposed to radiation, food additives, plastics, drugs, and other substances that may damage our genes, possibly adding more defective genes to the gene pool.

Joshua Lederberg, a Nobel-laureate geneticist, estimates that 80 percent of the mutations that occur are the result of controllable environmental factors. It is ironic that the human gene pool is acquiring more defective genes while modern medicine is helping more people survive and pass their genes on to their children.

Many scientists have expressed concern about the legal and ethical aspects of recombinant DNA technology. In 1957 scientists met to discuss the danger that harmful organisms might be created. As a result of the conference, these scientists voluntarily postponed their many experiments until government-enforced guidelines could be worked out.

Marketing Genes The biotechnology market has great potential. One agricultural study predicted that a $100 billion maket would develop by the 1990s. However, concern about commercializing of genetic technology has already erupted into legal battles between industry and universities.

Investors are competing to capture the market, and companies hire university based geneticists to serve as consultants or board members. Some geneticists have even started their own companies. Traditionally, scientists have been willing to share knowledge, specimens, and equipment. However, some people worry that this spirit of cooperation could cease if scientists become competitive in the corporate struggle to make profits.

Another concern is that private companies would be more concerned with the marketability than with the beneficial aspects of genetic engineering products. For example, human growth hormone can be given to children who suffer from dwarfism. More profitable, however, is bovine growth hormone, which stimulates the growth of normal cattle and thereby provides more saleable beef per acre.

Dilemmas like these will doubtless remain as long as genetic engineers probe into the fabric of life. Genes may control life, but humans are beginning to control the genes.

Questions for Discussion and Research

1. Should people with defective genes be kept alive, even though their genes might be passed to offspring?
2. If it becomes possible, should genetic engineering be used to "improve" people—to make them bigger, stronger, smarter? Who decides what an improvement is?
3. Should more money and research be directed to correcting genetic diseases by gene therapy, or to correcting the environmental factors that cause mutations?
4. If the military wants to use recombinant DNA to produce biological weapons, should this be allowed?
5. Should scientific knowledge be "sold" solely for profit?
6. Should genetic engineering be controlled in any way? If so, how and by whom—scientists, the government, citizen committees, others?

Essay 6
The Zoo—Prison or Refuge?

Zoos have fascinated people for centuries. The first recorded menagerie was run by Queen Hatshepsut of Egypt in the fifteenth century B.C. The queen brought exotic animals to live in her garden to amuse herself and her friends.

Throughout history, the rulers of great empires from China to Rome have kept menageries. Most of these zoos were places of entertainment, which sometimes included combat between animals and humans. Today's zoos are built to shelter and exhibit animals. The closest thing to combat is likely a monkey throwing peanuts at the spectators.

Understanding the Creatures Many people believe that the most important benefit of zoos is conservation education. It is hard to visit a zoo without feeling drawn to some of the animals; witness the crowds vying for a view of the famous Chinese pandas, or youngsters imitating the walk of penguins.

Supporters of zoos believe that face-to-face contact with bears and giraffes will do more for conservation than will pictures in magazines or documentaries on television. As the nineteenth-century writer Henry David Thoreau said, "Every creature is better alive than dead, men and moose and pine trees, and he who understands it alright will rather preserve its life than destroy it."

Many zoos have begun to take their educational role quite seriously. Often signs in front of pens give information about the natural habitat, diet, and social patterns of the animal. Some zoos also explain how people threaten the survival of certain animals. The Bronx zoo, for example, has a sign reading:

"Each year in the United States, 1200 square miles [3100 km^2] of animal habitat are replaced with asphalt and concrete . . . Each year Americans contribute 50 billion cans, 28 billion bottles, and 50 million tons of paper to rapidly growing dumps. These dumps are located in areas which once were rich with wildlife."

The Zoo as Laboratory The zoo is also a place to gain scientific knowledge. Biologists have been able to study larger animals (such as monkeys, lions, and elephants) in their natural habitats. However, it has not been practical in the wild to study the behavior of small animals who live underground or in other hidden places.

There are at present more than 500 000 wild vertebrates in approximately 500 zoos and aquariums around the world. Some naturalists believe that study of this reservoir of species can improve conservation practices. For example, they might learn how best to reintroduce captive animals to the wild and how to restore habitats.

Many zoo boosters believe that captive breeding is the only way to save species that face extinction. One example is the Père David deer (named for the French missionary Father Armand David, who discovered the animals in China). Most of the deer had been destroyed during a rebellion, but an English duke exported 18 of them for breeding on his estate in England. Now there are close to 800 individuals in various zoos, all descended from the duke's original stock.

Przewalski's horse is another example of a rescued species. It is the last of the true wild horses and had all but vanished from the Mongolian plains by 1960. Now there are only about 250 of them left, all in captivity. Among other endangered species kept alive and breeding in zoos are various exotic birds, the leopard, Siberian and Bengal tigers, the Asian one-horned rhinoceros, the scimitar-horned oryx, and the addax.

Breeding Problems Some zoo opponents charge that captive breeding is unsatisfactory. They fault the unnatural habitat, the

crowded living space, and the reduced gene pool due to inbreeding.

To assure the survival of a species in captivity, geneticists have determined that certain criteria must be met. One is that there must be at least 100 individuals in a population, at least half of them born in captivity. A random sample of zoos recently showed that the average species of mammal was represented by only three to five individuals. For educational reasons, zoos display as many different animals as possible, but space is limited. Thus, diversifying the genetic pool of each species takes second place to diversifying the number of species.

Ironically, the breeding programs for some animals have produced more animals than zoos can safely handle. An increase in population produces surplus males. Ideally, these males would be kept for genetic variety in breeding, but the cost of maintenance becomes almost prohibitive for a good-sized herd. Food for a zoo animal costs up to $2000 per year, and land for more animals is seldom available.

Room and Board Approximately 1 percent of the earth's land area is occupied by national parks and reserves. Many of these protected areas are located in species-poor regions, such as Northern Canada and Greenland. To represent all of the earth's ecosystems, much more space—especially in species-rich regions—would have to be used for parks and reserves.

Another criticism leveled at most zoos is that they are like prisons. Even large reserves do not provide the proper environment for many animals. Many species require large territories and varied ecosystems to survive. The cheetah, for example, needs an extensive area containing only a few individuals. In addition, tourists who visit zoos and reserves leave litter, feed the animals, and generally disrupt normal behavior patterns.

Special diets are still another problem. Herbivores need a daily quota of fresh leaves and branches from certain plants, carnivores usually prefer live food, and birds of prey require very special attention (not to mention the vampire bats, which need blood).

Clearly, the care and feeding of captive animals can be difficult. But as long as humans are fascinated by animals, there will probably be zoos. Prison or refuge? Nobody can ask the residents.

Questions for Discussion and Research

1. Should the objective of captive breeding be to keep animals as similar as possible to those in the wild, or simply to maintain them in captivity?
2. It is estimated that hundreds of species become extinct each year. Should we even try to preserve threatened species?
3. With many millions of people living in crowded and unhealthy conditions, should money and land be used to improve human lives rather than to build better animals reserves?
4. Can you think of ways to make zoos better homes for animals?
5. Should humans continue to keep zoos, or outlaw zoos? (If you think animals should not be kept in zoos, how do you feel about keeping animals as pets?)

Essay 7
Water for Life

Imagine waking up one morning to discover that your home had no running water. You would not be able to take a shower, make coffee, wash the dishes, flush the toilet, or water the plants. To get an idea of how much water you use every day, consider this: a dishwasher uses about 75 L per load and a clothes washer uses twice that much. A shower takes some 30 L every minute and flushing the toilet requires about 20 L.

Extend the no-water fantasy into your community. What would life be like without water for drinking, irrigating crops, fighting fires? Within a few hours, an inconvenience would become an emergency.

Our lives depend on the water supply. Each person needs about 2 L daily for survival. Industry and agriculture use over 7000 L daily per person. Demand will likely increase as our population continues to grow.

Where does all this water come from, and can we be assured of continued supplies? Whatever water we withdraw for personal and industrial use must somehow be replaced, or water resources will diminish drastically.

The Water Cycle Water covers about 70 percent of the earth. The amount of water on the earth is constant. Water continually circulates through the hydrosphere in a cycle. It evaporates from the earth in the form of vapor and falls back to the earth as precipitation.

Groundwater reservoirs near the surface are one major source of water supplies. However, it takes 5000 years to replace groundwater withdrawals. In 1975 groundwater accounted for 20 percent of water use, prompting the Water Resources Council to warn that groundwater "overdrafting" was occurring in 14 of the nation's 21 water resource regions. Rapid depletion causes water tables to drop, making pumping more difficult and expensive, causing sink holes, and leaking salt water into groundwater reservoirs in coastal areas.

The primary source of water supplies are rivers, because they are easily accessible. Although rivers are the smallest reservoir of the water cycle, water withdrawals are quickly replaced.

A major way people exploit river water is by building dams. Before 1900 only 41 dams with reservoirs were built. Today the number exceeds 2250, with a total storage capacity of 13 percent of the world's annual river flow.

Dams are used for hydroelectric power plants, flood control, water storage, and recreation. However, they have negative effects. Dams can flood valuable land, raise the water table, lead to changes in water temperature and the composition of substances dissolved in the water, and reduce the spawning waters of many fish species.

The Search for Water To avoid depleting water supplies, we will have to use alternative sources. One candidate is the ocean. Currently, the United States gets about 11 percent of its water from the sea. The use of saline water is expected to increase to 40 percent by 2020.

Salt is removed from sea water by various methods, including osmosis and evaporation with condensation. At present, the recovered water is used mainly for cooling in industrial processes and for making steam-electric power. Desalination is too expensive to economically produce water suitable for drinking and irrigation. However, advances in technology may someday make that possible.

There are other ways of increasing water supplies. With improved forecasting of rain and snow melts, the runoff could be used. Water transport methods could be improved to reduce losses. Reservoirs could be covered to lessen evaporation. Improved land management and pollution control could also save water resources.

According to estimates, cloud seeding can increase precipitation by 10 or 20 percent

over areas as large as 2600 km. Although seeding sounds promising, it could present problems by interrupting weather patterns.

Reuse of waste water is also important. Municipalities purify water for drinking by clarifying it with aluminum sulfate and chemicals that attract dirt. The water is then filtered through layers of charcoal, sand, gravel, and rock to trap the suspended materials. Finally, it is treated with chlorine gas to kill bacteria. Waste water is also recycled through sewage treatment plants to be used for irrigation and industrial purposes.

Tomorrow's Water Many scientists have made pessimistic projections about the amount of water that will be available in the United States in the year 2000. They base their argument on the predictions in the second column of Table 1.

Others are more optimistic. They think we will be forced to conserve and reuse water, and so our total water use will actually diminish during the next 20 years. Their argument is based on the events predicted in the third column.

Our dependence on water is as continual as nature's water cycle. We can take it for granted, or use it wisely.

TABLE 1. Predicted Water Use

Water Use	*Predictions Leading to Increased Consumption*	*Predictions Leading to Decreased Consumption*
Food canning, agriculture	More food grown and canned	Improved processing methods (dry peeling, more efficient washing and sanitation, recycling, use of conveyor belts rather than flumes); more efficient irrigation
Manufacturing (metals, steel, industrial chemicals)	Increased production	Cooling and recycling of water used for cooling and industrial processes
Power and fuels	Increased use; use of large amounts for safety in nuclear plants	Recycling of water used for cooling and other processes
Wood, lumber, paper	Increased production	Use of conveyor belts rather than flumes; improved processes; recycling of cooling water
General	Increased birth and immigration rates; new uses for water (for example, for new types of appliances)	Decreased birth and immigration rates; legal restrictions on water use; education; improved treatment and reuse of water

Questions for Discussion and Research

1. In making their predictions, what assumptions are the "optimists" and the "pessimists" making about the economy? about government controls? about human behavior? Whose argument do you think is more persuasive?
2. Which predicted factors would have the greatest impact on water use?
3. Should access to groundwater be controlled? If so, how and by whom?
4. Can you think of ways to save 40 L of water every day without any real sacrifice?
5. List several reasons for and against building a dam. If you can, use an actual dam or proposed dam as an example.

Essay 8
Acid from the Sky

In A.D. 79 the beautiful Italian mountain named Vesuvius erupted, burying the town and people of Pompeii. Along with the lava and fire disgorged by Vesuvius, significant amounts of hydrochloric acid spewed into the atmosphere. When the rains came, the acid washed down over Pompeii. Vesuvius was an early instance of a modern problem, "acid rain."

Acid rain, or more appropriately acid precipitation, is rain or snow that contains a mixture of strong mineral acids such as sulfuric acid, nitric acid, and hydrochloric acid. Other toxic chemicals may also be present. These include carbonic acid; heavy metals such as lead, cadmium, and mercury; and various other pollutants such as polychlorinated biphenyls (PCBs).

Pure rain is slightly acidic, with a value of 5.6 on the pH scale. This may be because water reacts with atmospheric carbon dioxide to form carbonic acid, and picks up sulfur dioxide emitted from volcanoes. Acid rain has a pH value below 5.6. The rain near Vesuvius, for example, has a pH as low as 2.8—almost 1000 times more acidic than pure rain.

Sources of Acid Precipitation Many sources of acid precipitation, like Vesuvius, are natural. For example, natural fires in exposed areas of coal generate large quantities of sulfur oxides, which are then converted to sulfuric acid. Coastal salt marshes produce sulfur compounds that are oxidized into sulfuric acid. In addition, the famous geysers and mudflats of areas like Yellowstone Park also emit sulfur compounds.

Most sources of acid rain, however, are created by humans. Coal-fired power plants spit out sulfur dioxides, and auto exhausts throw nitrogen oxide into the atmosphere. These chemicals mix with water in the air and return to earth as precipitation that is very acidic.

Acid Effects Many people are concerned about the effects of these acids on the ecosystems of streams and lakes. Especially vulnerable are those having beds of sandy soils, which are low in lime content. Soil containing lime has a high pH and can help neutralize the acids that are deposited by rain and snow.

The leaching of substances from soil into fresh water often harms organisms. Aluminum can inhibit spawning and hatching of fish and other animals, cause malformation of embryos, and retard growth. Aluminum in water is also toxic to plants.

Acid rain also lowers the pH of exposed soil. This makes important nutrients such as phosphates and minerals such as aluminum, iron, and calcium more soluble, and they are leached from the soil.

Substances leached from soils are carried by rainwater runoff to rivers and lakes, to wells, and to groundwater reserves. To make contaminated water suitable for drinking, elaborate processing techniques must be used.

The absorption of acid rain can cause chemical imbalances in soils. This affects seed germination and plant growth, which are dependent on proper soil pH conditions. To germinate, grow, and reproduce, seeds need a fine balance of temperature, light, and moisture. These conditions can be adversely affected by any chemical change in the soil.

The chemical changes in contaminated soils can favor new types of plants. These plants might compete with crops in farmlands. To save their crops, farmers would have to fertilize the soil to restore it to the original pH balance.

Scientists are also concerned about leaching of the essential nutrients phosphorus, potassium, magnesium, and calcium from forest soils. In the long term, perhaps in only a few decades, the increased acidity of soils could reduce forest areas.

Buildings, too, are blighted by acid rain. Soluble acids can extensively damage metals and corrode limestone structures and

monuments. Millions of dollars are spent each year to restore damaged buildings and statues.

No Boundaries Acid rain recognizes no boundaries. Winds and air currents carry acids afar, and the precipitation does not always fall on the country that produced the acids. Because of this, acid rain has become a touchy international issue.

In the late 1960s, Swedish officials estimated that about half of the acid precipitation falling in Sweden originated in Britain and West Germany. Over 10 000 Swedish lakes have a pH value below normal—some are as much as 1000 times more acidic than normal lakes.

Similar issues have soured relations between the United States and Canada. Canadian officials estimate that about half the sulfur deposited in Canada originates across the border. Only about 20 percent of the sulfur deposited in the United States comes from Canada. In 1980 the two governments officially agreed to reduce air pollution.

Some industrialists object that installing equipment to reduce emissions would be diffcult and expensive. However, there is evidence linking acid rain and industry's smokestacks. A 1983 report by the National Academy of Sciences stated that cutting sulfur dioxide emissions by 50 percent would reduce acid rain by an equal amount.

What Should Be Done? Various solutions to the acid rain problem have been offered. Some people believe that to "act locally is to act globally." A Minnesota law requires its Pollution Control Agency to identify state areas that are sensitive to acid rain deposits, to develop standards to protect them, and to control emissions.

One temporary measure is to put lime into lakes to neutralize the acid. However, lime can be applied to only a small fraction of the lake area, and it does not restore the lake environment to its original state. In fact, the lime may drastically alter a lake ecosystem.

Indeed, solving one problem can cause another. For example, two Cleveland Electric Illuminating (CEI) plants were pressured by the Environmental Protection Agency to reduce sulfur emissions. CEI proposed switching from high-sulfur to low-sulfur coal. However, low-sulfur coal could be found only in Kentucky and West Virginia. Thus, the decision would have cost thousands of high-sulfur-coal miners in Ohio their jobs. Yet, it would also have helped CEI comply with emission control standards and perhaps saved many types of ecosystems.

Questions for Discussion and Research

1. What decision would you have made for the CEI plants? Why?
2. Whose responsibility is it to ensure that pollutants do not contaminate neighboring territories? one government? both governments? the industries involved? an international group?
3. Should there be an effort to educate people about the hazards of acid precipitation? If so, what kind?
4. If there is only a certain amount of money available to deal with the acid precipitation problem, should it be used primarily to find ways to repair the damage, or find ways to control the sources?
5. What are some methods for decreasing emissions other than those described in the text? What are the economic consequences of the various methods?

Essay 9
Islands of Waste

On Ship Island, just off the coast of Mississippi, is a popular tourist attraction called Fort Massachusetts. During the 1970s high waves pounding against the fort began to cause structural damage. To protect the fort, the U.S. Army Corps of Engineers surrounded it with dredged material. This increased the island's area and absorbed the impact of the waves.

Vacation Island, in a California bay, also attracts tourists—water-skiers and boaters. It was created from dredged material. The dredged material used to make Vacation Island is actually garbage. If it had not been used to build, it would have been part of our growing waste-disposal problem.

The Waste Revolution When the American population was small and mostly rural, waste had little effect on the environment. Then the industrial revolution brought exciting new technologies, luring Americans to cities. However, the era of urbanization ushered in some complicated problems. One of the major problems was waste disposal.

After World War I, industries boomed and the economy became increasingly consumer-oriented. New products and packaging materials—paper, plastics, toxic chemicals, synthetics—not only added to the amount of waste, but also posed new disposal problems. Some of the materials, such as nonbiodegradable plastics, still defy disposal methods.

The Throw-away Culture In the late 1960s, a study of refuse production in New Haven, Connecticut, showed that a four-person family dumped 1800 kg of waste annually. In the 1970s, the nation produced an average of 170 million metric tons of trash per year. Along with this waste comes the cost of dealing with it. In 1980, Americans paid over $4 billion to collect and dispose of wastes from urban areas.

If these figures seem staggering, consider that municipal waste represents only 5 percent of the total solid waste in the United States. Of the rest, 4 percent is accounted for by industry and 91 percent by agriculture and mining.

Industries and cities have searched for inexpensive, effective ways of getting rid of waste. The two most popular methods have traditionally been dumping in the sea and dumping on unused parcels of land.

In 1934 the United States Supreme Court ruled that dumping of municipal waste at sea must stop. However, industrial and commercial wastes were not subject to this ruling. By the late 1960s an estimated 45 million metric tons of waste per year were being dumped into the ocean. By the 1970s there were about 120 waste disposal sites in the oceans, supervised by the U.S. Coast Guard. Environmentalists are still calling for stricter national regulations to prevent contamination of the ocean.

There are thousands of land dumps in the nation. Dumps occupy often valuable land, and can cause pollution. Burning trash produces smoke, fouling the air, and some waste contains toxic subsances. Dumps attract rats and insects, which carry disease-causing bacteria from wastes to people.

Legal Aid In 1965 President Lyndon B. Johnson called for federal legislation to help local governments develop programs for efficient waste disposal. Congress passed the Solid Waste Disposal Act of 1965, which initiated research into the problem and provided technical assistance to local agencies.

In 1970 Congress passed the Resource Recovery Act, which shifted the emphasis from disposal to recycling and the conversion of waste into energy. The act also set up a national system for storing and disposing of hazardous wastes. Subsequent laws have built upon the 1970 act.

Waste Lands Several alternatives to dumping waste have been tried. One is the sanitary landfill. In this method, layers of garbage and ashes are used to level roads,

fill ravines, or fill in marshland and swampy coastal land. Until the 1970s, sanitary landfills were considered the most desirable form of waste disposal because they were thought to be sanitary, economical, and produced "reclaimed" land.

However, problems were found with landfills. As cities grew, landfills had to be located further away, resulting in higher transportation costs. Reclaiming marshlands for human use made them unsuitable as wildlife habitats. Also, landfills could contaminate valuable groundwater and produce noxious fumes and gases. If fills are not properly ventilated, methane gas may seep through fissures and cause fires and explosions.

Some reclaimed lands have proved suitable for parks and parking lots, but not for houses or businesses. In New York, houses built on filled land developed cracks in the walls and tilted floors; they eventually were torn down.

Composting Another method of waste disposal is composting. This converts the organic portion of solid waste into a soil conditioner called humus. The conversion is accomplished by aerobic digestion, a biological process in which oxygen-using microorganisms decompose the organic materials.

Experts say, however, that composted refuse is a low-grade fertilizer that cannot compete with chemical fertilizers. Also, few areas in the United States need the type of soil conditioning offered by humus. The lack of a market and the high cost of processing make wide-scale composting impractical.

Waste Power The "energy crises" of the 1970s sparked interest in recovering energy from solid waste. About 75 percent of urban waste is combustible. In one recovery system, the heat produced in burning waste is used to generate electricity.

Pyrolysis is another method of converting solid waste into fuel. The wastes are heated in a low-oxygen atmosphere, where chemical decomposition takes place without combustion. However, most pyrolysis systems are still experimental.

Recycling Resource recovery, or recycling, was a patriotic duty during the two world wars to supplement scarce raw materials. Recycling was revived in the 1970s but has not been very successful. Separating the natural substances from synthetic materials is difficult. Also, recycled materials cost as much as virgin materials, which are higher in quality, readily available, and more homogeneous in composition. Tax allowances favor the use of virgin materials over recycled materials.

There seem to be drawbacks to every innovative method of waste disposal. Still, success stories like Ship and Vacation islands show that waste can be put to work.

Questions for Discussion and Research

1. Who owns the refuse from agriculture and industries that produce goods for general consumption?
2. Can a city charge its citizens for collection and disposal services and then use the waste or sell it to someone else?
3. Should citizens, industries, or government pay the high costs of more efficient use and disposal of waste?
4. Should the federal government impose stricter regulations on industrial waste disposal practices? If so, what types of regulations would be appropriate?
5. Can a consumer-oriented economy abandon the "throw-away" philosophy and still continue to thrive?

Essay 10
Our Battles with Insects

Night after night in the spring and summer of 1981, helicopters bearing chemical weapons passed over northern California's Santa Clara Valley. Though some outraged farmers fired shots at helicopters, the enemy was apparently vanquished. The enemy was not human, but the tiny, devastating Mediterranean fruit fly.

The helicopters dropped a sticky protein bait mixed with the insecticide malathion. Although many scientists said that malathion was relatively safe, others opposed its use. They feared in could cause birth defects and illness in humans.

However, something had to be done about the Mediterranean fruit flies. They eat 250 varieties of fruits and vegetables. Their attacks can wipe out fruit crops and ruin farmers. Malathion, which contains only small amounts of insecticide, is the most effective tool against large outbreaks of flies.

Chemical Killers Many insects, such as ladybugs and bees, are helpful to humans. Others, however, cause a great deal of damage. We wage war on these pests.

Until the past few centuries, most pests were natives of their particular ecosystems and were controlled by natural enemies. As trade increased, insects attached to fruit and other products were translocated. Without their natural predators in their new surroundings the insect populations exploded, creating serious problems. But, by the 1800s insecticides were developed and chemical control of pests became widespread.

Today, the tools of pest control are still largely synthetic chemicals. Some 200 basic chemicals are commonly used in agriculture, and are sold in thousands of different formulations under many trade names. The chemicals are categorized according to their intended targets: insecticides, rodenticides, fungicides, and herbicides. (Any term ending in *-cide* is the name of a poison.) Most can be called "biocides" because they kill living things. Such pesticides are used not just in agriculture, but also in public health, forestry, fish and game management, right-of-way maintenance, property protection, and recreation.

Saving Lives and Crops In recent decades, the use of pesticides has greatly helped to improve the yields per acre in forests, pastures, and fields. In 1920 one farm worker produced food and fiber for eight people, but in 1957 the ratio was one to 23. Pesticides, along with improved farming techniques and machinery, help farmers grow more food on less acreage with less labor.

In Third World countries, pesticides have saved lives and preserved crops. Millions have escaped malaria, typhus, and other diseases because of chemical control of disease-carrying insects. Agrichemicals have prevented famine and malnutrition by destroying hordes of locusts that attack crops in Africa and the Middle East.

Danger Chemicals for pest control pose hazards to human beings and to ecosystems. Many pesticides are nonselective, killing forms of life other than the targets. Many pesticides are chemically stable, remaining in soil, water, and living tissue rather than breaking down. The poisons can move up the food chain, killing plants, animals, and people. Also, poisoning by certain pesticides may cause cancer or genetic damage.

The Oxford Committee on Famine Relief, a British private aid group, recently estimated that each year 750 000 people throughout the world are poisoned by pesticides and that 22 500 of them die. In 1972 400 people in Iraq died and 5000 became ill after eating grain products that had been treated with an organic mercury fungicide. In 1976 five Pakistani field workers died and 2500 were stricken from mishandling pure malathion.

Moreover, insect populations can develop a resistance to a poison, rendering a pesticide useless. Although the insects become resistant, the insecticide might kill their predators. In Central America, for example, large cotton plantations were dusted about eight times a year. As the balance of natural predators and prey was altered by chemical control, fields had to be sprayed as often as 40 times every season to keep pests under control.

Nature's Way Some ecologists estimate that at least half the insecticides now used can be replaced by biological controls. These "natural" controls turn the environment against the pests. Predators can be released in an infested area. Another species can be introduced that will compete with the pests for food. Or, if the objective is to control disease rather than save crops, the pests' food supply can be destroyed.

Another technique is habitat modification. For example, swamps are drained to destroy the habitat of malaria-carrying mosquitos.

Still another method is to introduce sterile males into a population. Females who mate only with sterile males will have no offspring. This would reduce, or perhaps eliminate, the population.

A different type of biological control would focus on the crops. Plants could be developed that are resistant to pests and diseases.

However, biological controls are complex, may take years, and may not work. For example, many farmers and chemical producers say that it could take 10 to 15 years to develop, plant, and harvest resistant varieties of crops. During those years, producers would lose money and consumers would find food shortages. In the case of sterile-male releases, some scientists are skeptical. They doubt that the sterile males can successfully compete with wild males.

Clearly, the debate will continue on the usefulness of biological controls and on the hazards of pesticides. Meanwhile, the battle between humans and insect pests will rage.

Questions for Discussion and Research

1. Who should determine the proper pest control to preserve crops, ecosystems, and human lives—governments, chemical companies, scientists, individuals?
2. The aerial spraying to rid California of the Med fly cost $75 million. Was it worth it?
3. Are chemical producers responsible for educating people about the effects of their products? What if the users are far away and education would be expensive and difficult?
4. Should research be directed at reducing the hazards of pesticides or at finding workable alternatives?
5. Would you support alternatives if the method adds 10 percent to your grocery bill?

Essay 11
The Plants of Opportunity

May 18, 1980 began like any other spring day around Mount St. Helens in Oregon. Then, suddenly, an earthquake rumbled the volcanic mountain. Magma heated the ground water into steam, and the pressure caused Mount St. Helens to explode with a force comparable to a 400-megaton nuclear blast.

More than a cubic kilometre of ash was thrown into the atmosphere and hot debris and mud poured from the crater. Within about a 10-km radius, all life was destroyed. After the holocaust, Mount St. Helens looked like the surface of the moon.

Within about five months, scientists began exploring the disaster area. On the apparently dead mountain, they found signs of life had already begun to reestablish itself. The species of plants they found are what ecologists call "colonizers" of disturbed habitats. Most people would call them weeds.

A Weed Is a Weed Is a Weed How would you define *weed*? What is the difference between a "good" plant and a "bad" one? Having trouble? You are not alone. For decades, biologists have tried to distinguish "good" from "bad" plants, and the discussion still goes on. Perhaps the shortest definition ever devised states that a weed is "a plant out of place." Here are some other attempts to define weeds:

- a plant that grows in an undesired location (a definition offered by the Terminology Committee of the Weed Society of America)
- a plant with such competitive habits that it chokes out more nutritive plants
- a plant that is difficult to eradicate
- a plant that reproduces in great quantity (single, isolated plants are rarely considered weeds)
- a plant that is harmful to people, animals, or crops (some of these harbor viral diseases and nematodes)
- a plant that grows without cultivation
- a plant that is not valued for its beauty, resulting in disfigurement of the landscape

Notice that all these definitions are negative. However, the very characteristics listed in the definitions make weeds good colonizers after disasters.

Pioneer Plants Volcanic eruptions such as Mount St. Helens, floods, fires, droughts, and other catastrophes wipe out whole ecosystems many times a year. But the ecosystems can be reestablished by weeds. For it is the weed that arrives first in desolated areas, creating the environmental conditions in which insects, animals, and eventually other plants and trees can safely grow. This process is known as "ecological succession."

One reason that weeds make perfect pioneers is that their seeds travel easily. Some are so light that they can be carried great distances by the slightest breeze. Weed seeds also travel by other means, getting to a destination, it seems, by hook or by crook. They are carried on animals' fur, by ants, by earthworms, by irrigation ditches, and by water currents.

There are also perennial weeds, which do not die after seed production. A perennial survives the winter as an underground stem, then the plant emerges, flowers, and produces seeds in the spring, Bermuda grass (*Cynodon dactylon*), quack grass (*Agropyron repens*) and hoary cress (*Cardaria draba*) are perennials. (Interestingly, as more land is cultivated, weed roots are chopped up by the machines and scattered. This is beneficial for the weeds, but perhaps undesirable for the farmers!)

In addition, a weed produces so many seeds that dispersal covers a large area. A weed may use as much as 25 percent of its

energy for reproduction. Depending on the species, weeds produce from 5000 to 50 000 seeds per plant. By comparison, a common forest wildflower uses 1 percent of its energy to produce some 25 seeds.

Another timely characteristic of most plants considered weeds is that their seeds can remain dormant. Seeds may reach a disturbed area in which conditions are not right for germination. They can lie dormant until conditions are favorable—for years, if necessary—and then germinate. In fact, weed seeds found in anthropological sites hundreds of years old have been successfully germinated.

The Greening of Wastelands Weeds are tough. Many of these pioneering plants are able to tolerate intense light such as that found in flat, exposed fields. Some plants, such as the ragweed, can photosynthesize quickly in high light intensity and over a wide range of temperatures and concentrations of carbon dioxide. These weeds can move into a disturbed area and exploit environments that would be too severe for most other species.

As the weeds become established, they alter the nature of the ecosystem. They stabilize the soil by adding decaying products and establishing root systems, retard erosion, slow the wind, and provide shade. This creates an environment more suitable for less adverturous species.

After time, however, weeds that cannot compete with the newcomers disappear. Weeds spend so much energy in reproduction and in adaptation to harsh environments that little is available for longevity and competition. Although the weeds do not survive, many thousands of their seeds will have already colonized new frontiers.

Questions for Discussion and Research

1. If a species of weeds is extremely destructive to other plants or to animals, should it be destroyed?
2. Some weeds may have uses not yet discovered, as links in our food web or as medicines. How long should a "destructive" weed be studied to determine if it has hidden benefits? How do we decide if benefits outweigh harm, and vice-versa?

Essay 12
The Vanishing Rain Forests

In 1972 a primitive tribe called the Tasaday was discovered in a Philippines forest living just as our Neolithic ancestors did. Surprisingly, only 25 km of tropical rain forest separated them from the modern outside world.

The forest was not a barrier to migration for the Tasaday. Rather, it was such a hospitable environment that they had no need to venture farther. In the rain forest the Tasaday found food, shelter, and everything else they needed.

Shelter for Life Tropical forests comprise only one third of the world's forests but contain four fifths of its land vegetation. Some are as old as 60 million years. Today's rain forests support the richest variety of ecosystems on earth.

The rain forest biome has more species of plants and animals than all other biomes combined. A single hectare of forest in Brazil's Amazonia has 235 tree species, while the same area in a temperate forest usually has no more than 10 species. The Sunda Shelf in Southeast Asia contains 297 species of land animals and 732 species of birds. Europe, which is four times larger in area, has only 134 species of land animals and 398 of birds.

Tropical Treasures Tropical rain forest species have made significant contributions to human welfare. Such staple foods as rice, millet, cassava, pigeon pea, mung bean, yam, taro, banana, pineapple, and sugarcane originated in rain forests. These are just a sampling of the forest menu. In Indonesia alone, 4000 plant species are believed to be eaten by native peoples.

Also, rain forests are a natural pharmacy. They supply the majority of plants used in making drugs. The serpentine root, for example, has been used for 4000 years to treat dysentery, nervous disorders, snake bite, fever, and cholera. Currently, it is used to make a drug for high blood pressure and schizophrenia.

Rain forests can also provide natural insecticides—some tropical plants make compounds that repel insects. In addition, these forests contain materials for industrial use: latex, gums, camphor, resins, dyes, oils, and others.

Lost Forests Unfortunately, much of this rich resource is being lost. The main cause is the commercial use of timber. Almost every industry depends on forest products at some point. Wood is used in construction and as pulp for paper. It is part of a number of beverages and foods (including alcohol and some synthetic hamburgers), photographic film, explosives, and clothing. Wood is economical in comparison to materials like steel and plastic, which require more energy to produce.

Wood is also used for fuel. Estimates are that almost half of all wood cut worldwide each year is burned as fuel. Over four fifths of the fuelwood is used by people in developing countries.

The third largest threat to rain forests is cattle raising. In Latin America, large tracts of tropical forest are cleared to make grasslands for grazing. The grasslands last only about ten years before nutrients in the soil are depleted. When the grasses give way to scrub growth, the ranchers clear another patch of forest.

The Danger of Cutting In spite of the increasing demand for wood and space, critics are questioning the wisdom of clear-cutting rain forests. Some scientists speculate that cutting might affect climatic conditions in temperate zones.

Cleared lands reflect more solar heat than forested lands. This "albedo effect" may change global patterns of air circulation, wind currents, and convection processes. One possible outcome would be a decrease in rainfall over land masses, especially those north of the equator.

Another consequence of clear-cutting might be an increase of carbon dioxide in the earth's atmosphere. Tropical forests, like oceans, are natural "sinks" for carbon dioxide, which they absorb and use in photosynthesis. Excess carbon dioxide is added to the atmosphere by the burning of wood and fossil fuels. It is estimated that the amount could double by the year 2050. Because carbon dioxide traps sunlight in the atmosphere, the increase could produce a 2°C rise in global temperature. This warming could melt polar icecaps and markedly decrease crop production.

Rain forests cannot absorb the excess carbon dioxide if they continue to disappear at the current rate of about 245 000 km² per year. At that rate, they will be totally eliminated in under 40 years.

Fragile Forests Why are rain forests so vulnerable? Most tropical soils are very old and poor in nutrients. New nutrients are constantly added by decomposing vegetation, but high levels of rainfall prevent the formation of fertile topsoil.

Tropical trees have a root network three times as dense as that of temperate forest trees, enabling them to absorb almost 100 percent of the nutrients from rotting vegetation. Also, tropical heat and humidity decompose leaf litter within six weeks, as compared to one year in temperate forests. As a result, most of the ecosystem's nutrients are held by the vegetation and the soil is not very fertile.

When the forest is clear-cut, the soil becomes even less fertile. Heavy rainfall leaches the unprotected soil, pushing the few nutrients below the reach of pioneer plants, which have very short roots. In addition, the exposed ground hardens in the sun, causing water runoff and erosion, contaminating rivers. Once begun, the degradation becomes a vicious circle, creating an impoverished land.

Save the Forests? Recognizing the importance of tropical rain forests, many governments have launched campaigns to repair some of the damage. The Philippine government is trying to ban the export of unprocessed wood and has decreed that every male over ten years old must plant a tree each month. In 1978 Indonesia allocated over $2 million of its annual budget for wildlife and parks, cancelled one timber concession, and reduced the size of another. However, for some countries economic concerns outweigh ecological concerns. Consider the case of Kenya. Kenya's forests, which occupy less than 3 percent of its territory, have been steadily cut for timber and charcoal production. They are also threatened by developers who want to replace the native trees with exotic trees and agriculture.

As its own forests disappeared, Kenya has had to import expensive forest products. Consequently, it has initiated a massive tree-planting program in the forests to increase production of timber and other products. This program will upset the natural forest ecosystem. Other suitable planting zones would have required moving whole communities of people to make way for the trees.

Although the plantations will threaten the forests, timber exports could amount to $40 million per year—vital income for a developing country.

Indeed, the world's tropical forests are both valuable and fragile. Like the primitive Tasaday tribe they shelter, the rain forests are survivors from another time. Will they vanish tomorrow?

Questions for Discussion and Research

1. Did Kenya make the right decision in its tree-planting program? Why or why not?
2. Who should decide how tropical rain forests are used? local or national governments? an international group? scientists? timber or drug companies?
3. Suppose that a tropical plant was discovered that could cure cancer, but that harvesting the plants would eventually destroy the rain forest. What should be done?

Essay 13
New Gifts from the Sea

In 1872 the H.M.S. *Challenger* set out on the world's first expedition to study the seas. From the deep-ocean floor, *Challenger* dredged up mysterious black metal nodules. They looked like cricket balls, the scientists wrote, or potatoes. Inside, the nodules had treelike rings formed around a central "seed," such as a shark's tooth or the earbone of a whale.

The nodules are a lode of valuable metals—primarily manganese and iron, with small amounts of nickel, copper, and cobalt. In some areas they are so abundant that they resemble cobblestone paving on the sea floor. These nuggets are just one of the many treasures that lie beneath the world's oceans.

Mining the Seas Only recently has the technology been available for full-scale mining of the manganese nodules. Another possibility is to discover how they grow. One hypothesis is that the metals, which have an electrical charge, attract each other and stick together. Discovery of how they grow could lead to the development of "metal farms," where nodules are "planted."

The oceans contain every mineral found on land. For example, there is enough copper on the sea bottom to satisfy human needs for 60 centuries and enough nickel to last for 150 000 years.

One of the greatest mineral discoveries lies beneath the steamy, salty pools in the Red Sea known as the Atlantis II Deep. The gold, zinc, copper, silver, manganese, and iron there are valued at over $2 billion. In some places the mineral layers are 90 m thick. Since the layers sit on the surface on the ocean floor, they can easily be mined.

Sea Power Another seawater resource is the ocean's limitless supply of energy. The ocean's energy can be harnessed in several ways. One technique is called thermal water decomposition, in which high temperature is used to separate the hydrogen in seawater from oxygen. Scientists believe that the sun can provide the heat. Federal grants are funding research to perfect this process.

The tides are another source of energy. Some sections of the Gulf Stream carry 30 million cubic meters of water each second at speeds of 3 knots. The Department of Energy estimates that 180 million kilowatt-hours of power could be generated annually from the Gulf Stream flowing along the East Coast of the United States. The tides are already being exploited at a plant near Saint-Malo, France. It produces 600 million kilowatt-hours of electricity per year from tides that crash off the Normandy coast at speeds of over 50 knots.

Still another power source is biomass energy from plant matter. Kelp can be processed into methane (a valuable natural gas), used as a livestock feed, as fertilizer, and as a source of ethanol. Especially promising is the kelp *Macrocystis pyrifera*, which is fast-growing, shows no signs of aging, and replaces its fronds, doubling its mass every six months. An experimental farm near San Clemente, California has successfully produced methane gas from a crop of kelp. Projections are that a 40 000 hectare kelp farm could supply energy for 300 people and feed 3000 people.

Sea Foods Indeed, food is bountiful in the ocean. There are an increasing number of aquaculture projects to use that food. To some people, fish farming seems more promising and economical than cattle ranching.

If properly managed, a hectare of water can produce ten times as much food as a hectare of pastureland. At present humans obtain only about 50 million tonnes of food annually from the ocean, but about 90 million tonnes might be grown with a worldwide program of aquaculture. Already, United States companies have turned the aquabusiness into an $800 million annual retail industry. For example, Coca-Cola's

shrimp farm in Mexico should produce over 1000 kg per hectare of water each year.

Fish are not the only food source in the sea. Marine algae are a major base of the world food chain and are sources of food, drugs, industrial chemicals, cosmetics, and animal feed. Tens of thousands of algal species have been identified, but fewer than a dozen have been considered for human consumption.

Marine algae might replace some wheat and soybeans as livestock feed, releasing extensive tracts of land now used to grow food for animals. One potential food source is a microalga called spirulina. Although spirulina has little vitamin C and vitamin B6, it contains all 22 amino acids and its usable protein is second only to that in eggs.

The Law of the Sea Who owns these valuable resources? Traditionally, access to ocean resources has been unrestricted, which favored developed countries. For example, they hauled in about two thirds of the world's fish catch in 1975, some of it from the coastal waters of less developed countries.

However, demands for equitable sharing of resources have resulted in a Draft Convention on the Law of the Sea. This gives coastal countries a 320-km zone off their coasts, in which they have exclusive rights to explore and harvest the sea's resources. According to the treaty, these coastal countries must share their surplus with countries that have no coasts, and consult them about exploitation of resources.

Ironically, while we seek the salt-water treasures, we also use the ocean as a global garbage dump. Sewage, radioactive wastes, and tonnes of garbage endanger sea life.

The oceans cover 70 percent of the earth's surface. We must learn how best to use this vast reservoir—and how to protect it.

Questions for Discussion and Research

1. Do you think people would eat seaweed "steak" and microalgae "salad?"
2. What rights should land-locked countries have to coastal waters?
3. Should access to the seas outside coastal 320-km zones be unrestricted?
4. Should exploitation of ocean resources be controlled by the government? Or, should industries be allowed to develop the resources and sell the products for profit?
5. Using the sea's resources would greatly affect ecological relationships. For example, diverting wave energy to a power plant might alter beaches. What are other possible effects of resource exploitation? How can we determine if these effects would be harmful?

Essay 14
Struggle for the Land—To Develop or Preserve?

In 1967 the battle for Mt. San Bruno began. The mountain, located south of San Francisco, was part of a 1000-hectare parcel owned by the Crocker Land Company. The company planned a development there of 12 500 housing units, with a 500-hectare regional park on top of Mt. San Bruno. The development seemed to promise something for nearly everyone—construction work, low-priced and middle-priced homes, and recreation.

In compliance with governmental regulations, the developers presented their proposal to the county Parks and Recreation Commission and the county Board of Supervisors. These groups recommended that a committee study the proposal for a park and hold public hearings before approving the plan. Crocker also agreed to submit to hearings and investigations into sewage treatment facilities, road access, and other specifications necessary for new developments.

Then, citizen groups and public agencies began to object to the proposal. They complained that the development would increase the population of an already overpopulated area. They warned of increased traffic, more crowded schools, greater air pollution, and higher taxes in surrounding cities.

Many wanted to preserve the mountain in its natural state. In particular, they were concerned about two endangered species of butterflies, which are not known to live anywhere except on the slopes of Mt. San Bruno. The environmentalists dramatized their point by bringing a goat to one hearing. The development, they claimed, would so ruin vegetation and wildlife that only goats would be able to survive.

Developers responded that the development would make valuable contributions to the area and provide construction jobs. They pointed out that even people who could not afford the new homes would benefit. These people would have a chance to buy the older, often less expensive homes vacated by those moving into the development.

Furthermore, Crocker believed that the planned development would accommodate the inevitable population growth by making efficient use of the land. Traffic and pollution would not be a problem, they said. A proposed public transportation system would cut down on much automobile use.

After nine years of wrangling, a decision was reached. It was a drastic compromise for the developers: the proposed 12 500 housing units were slashed to 2 235 units. Considering the increased costs of labor and materials since 1967, Crocker decided that it could not build marketable houses at that level of output. The company abandoned the project. It now appears that another developer will build housing there under the terms of the compromise.

Face of the Land Often throughout human history, various groups have struggled over land. The earth has a land area of 150 million square kilometres. Only about 30 percent of it is potentially farmable. Roughly 20 percent is uncultivable mountainous terrain, about 20 percent is desert, 20 percent is tundra and glaciers, and 10 percent consists of other types of land with poor soils.

Much uncultivable land is also inhospitable. Most of us would not choose to live in such places as the Antarctic, the Arctic, the Amazon basin, swamps, deserts, and steep mountains. Not surprisingly, then, humans have built cities and factories on some of the most fertile land.

In the United States each year, almost 1 million hectares are paved, mined, settled, or otherwise developed. Only about 5 percent of the nation's land remains a wilderness. For every hectare of this land, there seems to be someone with an idea about how it should—or should not—be used.

The Land Rush The United States is extraordinarily rich in natural resources—fertile soil, forests, lakes, rivers, and spacious lands. Americans, and much of the world, depend on the use of these resources. The value of American agricultural and forest exports, for example, is far greater than the value of oil imported from the Middle East. Forest products come from logging, and often clear-cutting, of forests. Agriculture requires vast tracts of land and can forever alter the face of the terrain.

Much land is also used for building. The human habitat is not land in its natural state. People need houses, schools, offices, factories, shops, hospitals, transportation, and recreation areas. To some extent, then, we are all developers.

Pressure to develop will likely increase. The Census Bureau predicts that between 1985 and 2000 the American population will surge by some 30 million people. They, too, will shape the environment to fit their needs.

State of Nature Americans have always had the drive to develop the land. When pioneers pushed westwards, settling the continent with hammer and plow, the amount of land seemed limitless. It is not.

Concern that we are losing unique natural lands has sparked a widespread environmental movement. Human interference with nature, say environmentalists, throws ecosystems out of balance. Thus, they want to preserve many natural areas.

Ecologists believe that natural areas play an essential role. They absorb pollution, stabilize water and biochemical cycles, moderate climate, and accomodate flood waters. Natural areas provide a habitat for wild plants and animals, whose gene banks are necessary for maintaining the ecosystem.

In the last hundred years, the United States has preserved large areas of natural landscape. Funding comes from federal, state, and local governments. Lands are held in national parks and forests, state parks, the Wilderness Preservation system, the Wild and Scenic Rivers system, the National Wildlife Refuge system, and the Alaska Native Claims Settlement.

Environmentalists would like to see the government use these systems to acquire more natural areas for protection. Some also believe that local taxpayers should bear the responsibility for upkeep of nearby parks and reserves. This, they hope, would reacquaint people with nature and give them a stake in preserving it.

Finding a Balance The struggle for the land is not simply a clash between development and preservation. Few environmentalists would wish to protect every tree from the logger's axe. Few developers would want to build on every scrap of land.

Rather, the struggle is to find the best way to balance human needs and preserve the ecosystem. "All the land we're ever going to have is in front of us," said Tom McCall, former governor of Oregon. "We can't accept our past use and misuse of it as a guide for the future."

Questions for Discussion and Research

1. Can you think of alternative ways of funding public recreation areas?
2. Who should decide which lands should be preserved?
3. Can you think of ways that developers can lessen the impact of their building of the environment?
4. Could natural areas be preserved and used at the same time? For example, could some logging be done in a forest without damaging the ecosystem?
5. Would you give a higher priority to preserving land or to building new houses and industries? Why?

Essay 15
Why Do We Grow Old?

John S. is only 55 years old, but he seems much older. He cannot remember where the butter is, he often wears two shirts at the same time, and he wanders off if not watched. John S. suffers from Alzheimer's disease, the major cause of dementia (loss of mental capacity) in people over age 40.

Until recently, John would have been called prematurely senile. *Senile*, which literally means "old," is also used to describe dementia. Senility was long thought to be the inevitable companion of old age. But recent brain research has shown that several types of dementia are caused by physical or chemical abnormalities.

Alzheimer's disease, for example, has several possible causes. The most popular theory states that there is lack of the chemical messenger acetylcholine, a crucial link in memory and other nervous system functions. Acetylcholine is produced by a structure deep inside the brain called the nucleus basalis. Neurologists hope that future technology will make it possible to cure Alzheimer's disease by transplanting this structure.

The Mystery of Aging Medical research is beginning to find the physiological causes of many diseases that can afflict older people. However, the aging process itself still remains a mystery.

Aging is often accompanied by physical changes. These include a lower capacity for using oxygen, less muscular strength, slower transmission of nerve impulses, a declining ability to reason, and slower kidney function. Organs and tissues deteriorate because their cells stop functioning. Some deteriorate faster than others—the most vulnerable are those made up of cells that do not divide, such as muscle and nerve tissue.

The Error Theory Scientists are trying to find out why cells malfunction. One theory, known as the "error theory," states that the body gradually accumulates errors and does not correct them. There are several hypotheses of how body errors occur.

One idea focuses on "age pigments," brown granules in the nerve and heart cells of old people. This pigment hypothesis states that the granules, which result from the incomplete breakdown of fats, accumulate until the cells are so clogged that they cannot function properly.

Another hypothesis states that as we grow older our cells fail to make the right proteins because of random cell mutations or errors in making RNA from DNA. With increasing numbers of abnormal proteins, the cells eventually malfunction. A related idea is based on the fact that, as cells age, proteins and other complex molecules begin to unravel and so cannot function.

According to another hypothesis, large molecules cross-link with each other to form structures having no useful function. Research has focused on collagen and elastin, which are proteins found in connective tissue. Cross-linking causes collagen to shrink and form rigid clumps, which could account for stiff joints and wrinkled skin. However, collagen cross-linking occurs outside cells and is thought to be complete by age 40.

Still another hypothesis blames the immune system. Antibody-producing cells may become damaged and unable to produce antibodies. Also, the immune system may have difficulty distinguishing between foreign invaders and the body's own cells and may attack body cells as if they were bacteria.

Another possibility is that molecular fragments called free radicals, which are chemically unstable, break down vital parts of an organism. For example, they may cause abnormal breakdown of fats (producing age pigments) and cell membrane malfunction.

The Time-Clock Theory All of the hypotheses described above support the error

theory. But there are other theories of why we age. The "time-clock theory" says that an organism has only a certain amount of energy to expend during its lifetime. When that is used up, the organism dies.

However, many of the elderly live in nursing or retirement homes. Although medical care is close by, this kind of segregation often leads to physical and psychological problems. With continued research on aging, it may be possible to treat the ailments that now confine people to nursing homes.

The time clock may exist in the genes. In one experiment, a researcher discovered that in a culture, human embryonic cells multiply only 50 times before dying and adult cells only 20 times before dying. Also, as cells age, they divide more slowly. However, cells may behave differently in the body.

Other proponents of the clock theory suggest that the time-piece is in the hypothalamus, the brain organ that regulates hormone secretions. Hormones affect such major stages as prenatal development, puberty, and menopause—perhaps they also influence the aging process and death.

Living Longer, Living Better The cause of aging may well be a combination of these theories, or others yet to be suggested. But just as important as finding the cause is understanding that aging does not necessarily mean incapacity.

In this century, the human life expectancy has increased from 47 to 73 years, thanks to better nutrition and the control of infectious diseases. Medical advances have also helped older people to lead healthier, more productive lives. There are people in their seventies running businesses, running marathons, even climbing mountains.

Finding out why we grow old is a fascinating question for scientists. Deciding how to live when we are old is a question for all of us.

Questions for Discussion and Research

1. Should medical research money be used especially for investigating the aging process?
2. If older people become incapacitated, should their families take care of them at home or put them in nursing homes? Who should bear the costs of institutional care—the family or the government?
3. If old people are healthy should they be forced to retire to open jobs for younger people?

Essay 16
Sexually Transmitted Diseases

> The cheerful glories of his eyes decay
> And from his cheeks the roses fade away.

These lines were written in 1530 by an Italian doctor to describe the effects of a dreadful disease. The poem tells the story of a shepherd boy named Syphilus who insulted the sun god of Haiti. As punishment, the boy was given the disease that now carries his name.

Syphilis is one of several diseases that are transmitted by sexual contact. Formerly known as venereal diseases, they are now called sexually transmitted diseases.

Sexually transmitted diseases affect people of all ages, social classes, and ethnic groups. About 27 000 new cases are reported each day in the United States, and an estimated twice that number go unreported. Unless these diseases are treated promptly, they can cause pain, damage, and even death.

Syphilis This disease is caused by a spirochete (a corkscrew-shaped bacterium) known as *Treponema pallidum*. Like many other microbes that cause sexually transmitted diseases, the spirochetes thrive in moist, warm environments. Thus, they can easily penetrate the rectum, penis, vagina, and linings of the mouth. They can also enter the body through a cut if that part of the body touches live syphilis germs. The spirochetes usually die quickly when exposed to air.

Syphilis has three active stages. The primary stage begins from 10 to 90 days after infection. A painless sore called a chancre usually appears at the place where the spirochete entered the body. Chancres are full of live germs and are very infectious. Without treatment, they usually disappear between six weeks and six months. The spirochetes, however, remain in the bloodstream.

The secondary stage usually occurs within one to six months after the chancre has healed. The signs include flu symptoms, some hair loss, and a rash that does not itch. The rash, which lasts from six weeks to six months, is infectious.

When the symptoms of secondary syphilis disappear, the person is no longer infectious. (However, a pregnant woman can give the disease to her embryo.) This latent period, which has no symptoms, can last from one to twenty years or longer. During that time, some people's body defenses are strong enough to kill syphilis. In many others, however, the spirochetes migrate to organs and multiply, slowly destroying normal tissue.

The tertiary stage begins when the damaged organs cause pain. About one third of the people who contract syphilis and are never treated reach this stage. Half of those who have tertiary syphilis will die of cardiovascular and nervous system disorders if they are not treated.

Syphilis can be cured by treatments with penicillin or other antibiotics, either through injections or capsules. Only a few doses are usually necessary. However, early treatment is vital to avoid damage to the body and prevent transmitting the disease.

Gonorrhea Another dangerous sexually transmitted disease is gonorrhea, which is much more common than syphilis. Gonorrhea is caused by the gonococcus *Neisseria gonorrhoeae*. Like the syphilis spirochete, it is most commonly passed from the mucous membranes of one person to another during sexual contact.

Symptoms in males are painful urination and a discharge of pus from the penis. In females, there may be a discharge from the vagina. Frequently, however, people who contract gonorrhea do not have obvious symptoms. This occurs more often in females than in males.

The infection spreads through the sexual organs, and the damaged tissues are covered

by scars. This scar tissue can block the sperm tubes in men, causing sterility. In women, the gonococcus can cause pelvic inflammatory disease (PID) and scar tissue can block the fallopian tubes, preventing ova from passing into the uterus.

Treatment for gonorrhea is similar to that for syphilis. The antibiotic most commonly used against the gonococcus is tetracycline.

Herpes The much-publicized herpes is extremely contagious. There are actually two herpes viruses: *Herpes simplex* virus type 1 and type 2. Traditionally, the distinction between them has been that type 1 causes cold sores on the mouth and type 2 causes genital sores. However, some scientists say that the two strains are more closely related than was commonly thought.

The herpes virus enters the body through mucous membranes or skin abrasions. It reproduces in surface cells and can easily spread with the help of moisture and friction.

At this stage, symptoms occur. Genital herpes usually produces a cluster of sores, similar to blisters, each about one-third of a centimetre in diameter. The sores may be on the penis, labia, thighs, lower abdomen, buttocks, around the anus, around the cervix, or in the urethra. Other symptoms can include pain in the area of infection, fever, headache and a rash.

Eventually, the virus enters the nerve endings near the initial rash and migrates along the nerve cells to a ganglion just outside the spinal cord. The virus then becomes dormant: there are no symptoms and the disease is not contagious. At intervals, however, the virus becomes active again and migrates back to the surface of the body. Symptoms usually recur, though generally not as severly as during the initial outbreak.

Whenever the virus is active, the disease can be transmitted to another person. Therefore, all sexual activity should be stopped until the lesions disappear.

Self-innoculation is also possible. By touching an active sore, a person can transfer the virus to another part of the body.

The Search for a Herpes Cure Researchers have not yet found a cure for herpes. A vaccine developed in Britain shows "promise" of both curing and preventing herpes, but is still in the testing stage.

One treatment already available is an antiviral drug called Zovirax (Acyclovir). Acyclovir can be used only against active, not dormant, herpes. When applied to the sores in large quantities, it has effectively controlled serious herpes reactivations. However, the treatment is not appropriate for ordinary cases because it often involves intravenous or continual application that can be provided only in a supervised setting. In addition, many researchers believe that Acyclovir should only be used during the initial outbreak to avoid mutation of the virus to a form tolerant to the drug.

Trying to prevent recurrences is another approach. Because stress (such as anxiety, fatigue, heat) can trigger an outbreak, reducing stress can keep the virus dormant. For example, when a tingling sensation signals an outbreak of oral herpes, placing an ice cube on the spot can often prevent the attack.

Questions for Discussion and Research

1. How can you protect yourself and others from sexually transmitted diseases?
2. How would you react if a close friend told you he or she might have a sexually transmitted disease and would not see a doctor for fear that others might find out?
3. Should people under the legal age of consent be allowed to get treatment for a sexually transmitted disease without their parents' consent? Why or why not?
4. To curb the spread of contagious diseases, health officials might ask very personal questions, or quarantine contagious victims. Should people have the right to refuse to answer such questions, or to break quarantine? Should health officials have the right to do whatever they deem necessary to control the diseases? Why or why not?

Essay 17
Wonder Drugs

In 1935 a group of German scientists announced the discovery of a new drug called Prontosil, which acted against infectious bacteria. This was the first of the "wonder drugs." Its discovery marked the beginning of the great drug therapy era.

Since that time, many deadly infections have virtually disappeared. With the use of antibiotics, deaths from tuberculosis have decreased from 200 per 100 000 persons in 1900 to almost zero today. The syphilis death rate dropped greatly after penicillin (the first antibiotic) was discovered. A host of other serious diseases—including acute rheumatic fever, puerperal sepsis, pneumonia, scarlet fever, streptococcal septicemia, meningococcal meningitis, typhoid fever—are controllable thanks to the wonder drugs. In addition, diseases such as osteomyellitis, mastoid infection, and brain and lung abcesses that once required surgery are now treated by antibiotics.

These drugs have also reduced medical expenses. In the mid-1930s, a severe streptococcal infection could cost $500 for hospitalization—and sometimes funeral expenses. Although today's antibiotics are considered expensive (a typical prescription of penicillin costs $10 to $12), they can usually cure the infection without need for hospitalization.

Limits to Wonder Wonder drugs, however, have come under fire. Critics insist that they should not be used indiscriminately—for example, to prevent infections in patients who undergo uncomplicated surgery. Many scientists believe that antibiotics given for the common cold, influenza, and other viral infections are useless, because viruses are largely invulnerable to all known drugs. Still, other people believe that antibiotics can cure any infection.

One problem with antibiotics is that repeated use can result in sensitization or allegic reactions. Approximately 300 people die each year from allergic reactions to penicillin. However, most people are not harmed by careful use.

Another hazard of overuse, especially of antibiotics like tetracycline that work against a spectrum of diseases, is the destruction of beneficial bacteria. The body has many kinds of bacteria, which hold each other in check. When some are eliminated, the survivors multiply in great numbers and can cause a dangerous superinfection. If these survivors are drug-resistant, the effects can be even worse.

Drug resistance can be transferred from one bacterium to another by passing the genetic material that contains the resistant trait from one germ to another. For example, the intestinal bacterium *Escherichia coli* may develop resistance to antibiotics. The *E. coli* could then pass its resistance characteristic to a harmful bacterium such as *Shigella*, which causes dysentery. Curing the *Shigella* infection would be extremely difficult.

Resistant bacteria also transmit this trait to future generations. In fact, the widespread use of streptomycin has produced strains that actually cannot live *without* the drug.

Side Effects Many concerned people believe that no antibiotic is completely safe. Due to side effects and complications, many can cause illnesses more severe than the diseases they are combating.

Chloramphenicol, for example, is an important drug used to treat typhoid fever. Occasionally, however it also destroys blood-forming cells of the patient's bone marrow, resulting in blood diseases. Five million cases occurred before doctors found that chloramphenicol was the culprit. In the meantime, it had been used unnecessarily when less toxic drugs could have been given.

Drug Testing Proving a drug safe is a difficult task. Tests on animals are the first step. However, many people question the relevance of animal studies because of the dif-

ferences between humans and animals. A drug interacts with chemicals in the body, which differ in humans and animals. For example, penicillin is not very toxic to humans, but even small doses will kill a guinea pig. And a dose of morphine that will only anesthetize a dog can kill a person.

When researchers have finished animal tests, they begin tests on a small group of healthy human volunteers. This group receives limited doses at first. If nothing happens, the dose is gradually increased until the subjects begin to show evidence of toxic effects. Then the dose is cut back and the physical condition of the volunteers is closely studied. Since people vary in their responses, the drug must be safe for all the volunteers.

The drug is then tested for its effectiveness against the disease for which it is intended. The only way to do that is to give the drug to diseased people and wait for results. Finally, a report is submitted to the government for approval. Even after approval is won, evaluation continues. After the drug has been approved, it is up to the doctor to evaluate the patient and prescribe the right antibiotic for the right disease.

Certainly, drug testing is an inexact science. Approved drugs sometimes cause problems, even death. However, they far more often save lives.

Questions for Discussion and Research

1. Should drug research be carried out on human subjects? If so, how?
2. Should testing procedures on antibiotics be more strict?
3. Should antibiotics be freely available to the poor? to everyone? Who should subsidize the cost?
4. Should patients inform themselves about the possible problems and side effects of drugs, or simply trust their doctors to make the right prescriptions? How can people become informed?

Essay 18
The Price of Safety

In 1775 Sir Percival Pott published a research paper about cancer: "Chirurgical observations relative to the cataract, the polypus of the nose, the cancer of the scrotum, the different kinds of ruptures, and the mortification of the toes and feet." The paper showed that chimney sweeps were more likely to contract cancer of the scrotum than other men in the population.

One hundred years later, skin cancer was linked to exposure to coal tar, a substance chemically related to soot. As research progressed, other occupational hazards were identified. More and more people wondered whether it was safe to go to work.

Hazards on the Job The list of work-place substances that can harm workers is a long one. It includes lubricating oils, dyestuffs, radium paint, cadmium, hair dyes, arsenic, asbestos, vinyl chloride, pesticides, and plutonium, among others.

The effects of asbestos have received much scrutiny. Mesothelioma, a rare cancer of the membranes lining the chest and abdominal cavities, has been closely linked to exposure to asbestos. Asbestos is also implicated in many cancers of the larynx, lung, and gastrointestinal tract. About one-half of asbestos workers die of cancer. In addition, research indicates that the risk of cancer is greatly increased by exposure to both asbestos and smoking.

Asbestos workers also endanger family members, who are exposed to asbestos dust and fibers in work clothes. The general public is exposed to asbestos fibers in the air from insulation, and in food and water from various sources.

Another concern is that storage of dangerous substances in the work place might contaminate nearby areas. Some cancers have been linked to indirect exposure to toxic chemicals. A woman living downwind from a plant using vinyl chloride (VC) died of hemangiosarcoma, a rare cancer of connective tissues. For a long time, vinyl chloride has been suspected of causing this type of cancer.

Vinyl chloride is a chlorinated hydrocarbon used as an aerosol propellant. It is also the key component of polyvinyl chloride (PVC), found in such commonly used products as records, boots, furniture, pipes, wrapping paper, and electrical insulation. Although PVC itself is not hazardous, the carcinogenic vinyl chloride frequently is released from the compound.

Government Guardians To protect workers against such hazards, Congress in 1970 set up the Occupational Safety and Health Administration (OSHA). OSHA establishes standards of acceptable exposure to hazardous chemicals and other pollutants.

Three types of standards are set by OSHA. Concensus standards, recommended by a group of government and industrial scientists, define acceptable exposure to hundreds of chemicals at the work place. Permanent standards extend regulations to include work practices, monitoring, and medical surveillance. Temporary standards are effective for a six-month period, and may become permanent.

However, standards are difficult to set because scientists are not sure how to assess the hazards of exposure at any level. For example, old standards allowed workers to be exposed to vinyl chloride at concentrations of 1500 milligrams per cubic metre (mg/m^3) of air. When four workers died of hemangiosarcoma after exposure to vinyl chloride in 1974, OSHA issued a temporary emergency standard of 150 mg/m^3. Later, it set a permanent standard of only 3 mg/m^3.

OSHA has been accused of setting different standards for the work place than the Environmental Protection Agency (EPA) sets for the general public. A factory worker can be exposed for eight hours every day to 13 mg/m^3 of sulfur dioxide, but the EPA limit for the public is 1.3 mg/m^3 for three hours once a year.

The Bureau of Labor Statistics, after conducting an 18-state survey, estimated that 44 000 employees filed worker's compensation claims in 1980 for occupational injuries and illnesses associated with exposure to certain chemicals. According to the Bureau, these statistics represent less than 2 percent of all claims for occupational illnesses filed that year.

The Regulation Debate Some companies, however, feel that the government is overregulating industry. It can cost a lot of money for a company to comply with OSHA's safety regulations. It can also cost in efficiency when workers have to wear cumbersome protective clothing or equipment.

Such costs, say critics of OSHA, increase the costs of making products. The products then must be priced higher, possibly making them unmarketable. This could eventually lead to factory shutdowns and loss of jobs.

On the other hand, some people believe that regulating safety in the work place is worth whatever the costs may be. Any expense for that purpose, they say, is an investment. Healthy employees work harder, produce more, and take fewer sick days.

Still, critics see another problem with regulation—the difficulty of protecting workers from carcinogenic substances. The time between first exposure to dangerous compounds and the first clinical evidence of cancer averages 20 to 35 years. It is hard to know which substances are hazardous, and whether workers have been exposed to harmful amounts.

Every year, between 100 000 and 200 000 new synthetic chemicals are offered to companies, although only a few hundred are actually used. Only a small percentage of the new chemicals are evaluated for potential hazards. This means that there are many untested chemicals now in use.

However, some industrialists and some scientists find even the current evaluation methods too strict. They say that the government should give more weight to the economic benefits of potentially hazardous materials before restricting their production and use. They also believe that chemicals that do not cause mutations should not be strictly regulated.

Until the causes of cancer are better understood, states another argument, regulators should not be so quick to label a chemical carcinogenic. One suggestion is that the EPA and OSHA rely less on laboratory tests on animals and more on historical data of sickness and death in people exposed to chemicals. Thus, only those substances that are proven hazardous to people would be controlled.

Safety Awareness Many states have begun to enforce legislation requiring businesses to disclose to their employees and the public the potential health hazards of all toxic materials used on the job. These "right-to-know laws" would require employers to describe symptoms of exposure and procedures to take in emergencies. Some manufacturers say that complying with such laws would be expensive and would endanger trade secrets.

However, to promote on-the-job safety and awareness, many companies are already training their employees to understand and safely use hazardous materials. They believe that self-regulation is more effective than government regulation, and protects workers just as well.

Questions for Discussion and Research

1. Whose responsibility is it to regulate limits of exposure to any substances? government agencies? unions? individual companies?
2. Who should pay for the research and implemenation of safety measures?
3. How can individuals become informed about occupational hazards and protect themselves at work and at home?

Name ______________________ Date ____________

Laboratory Skill 1
Safety Guidelines and Laboratory Techniques

Safety in the Laboratory

1. Be familiar with safety equipment such as the first aid kit, fire extinguisher, fire blanket, emergency shower, and eye-wash.
2. Follow your teacher's instructions for handling corrosive, flammable, or volatile chemicals.
3. Immediately notify your teacher if dangerous chemicals are spilled.
4. Wear safety glasses when handling dangerous chemicals.
5. To smell chemicals, fan the vapors toward your nose rather than sniffing directly.
6. When diluting acids or bases, pour the concentrated reagent into the water—not the water into the reagent.
7. Wash your hands after handling chemicals, cultures, plants, or animals.
8. Position electrical cords so that they do not trip anyone.
9. Use hot pads or tongs when handling hot equipment.
10. Use a striker when lighting a burner instead of a match.
11. Use an open flame only for sterilizing equipment—not for heating substances—unless otherwise instructed by your teacher.
12. Do not pour hot liquids into plastic containers.
13. Do not use cracked or chipped glassware. Dispose of it as instructed by your teacher.
14. When carrying large or heavy equipment, support it from beneath with one hand.
15. Tie back long hair and roll up long sleeves when working with flames or chemicals.
16. Do not eat or drink while in the laboratory.

Laboratory Techniques

1. When shaking a bottle to mix the contents, plug the opening with a stopper—not your thumb.
2. Never pour a solution back into its bottle. Discard unused portions.
3. When pouring liquid into a small-mouthed container, use a funnel. Pour slowly so that the funnel does not overflow.
4. Let glassware air-dry rather than drying it with a towel.
5. A graduated cylinder, when not in use, should be laid on its side so that it will not be knocked over.
6. Pipetting techniques:
   a. Do not put the pipette into a reagent bottle. Pour some liquid into a beaker, pipette from the beaker, and discard any liquid left in the beaker.
   b. To draw up liquid, hold the forefinger—not the thumb—over the top end of the pipette. With the finger, you will be able to control the liquid better. Be sure the finger is dry.
   c. To eject liquid, remove finger from the top of the pipette and allow the liquid to drain. Do not blow the liquid out of the pipette. When the flow stops, touch the pipette tip to the side of the container for ten seconds to drain the last bit of liquid.
   d. Do not let the pipette touch the bottom of the container when drawing up or ejecting liquid.

Name ______________________________ Date ____________

Laboratory Skill 4
Collecting Data

Temperature (thermometer)

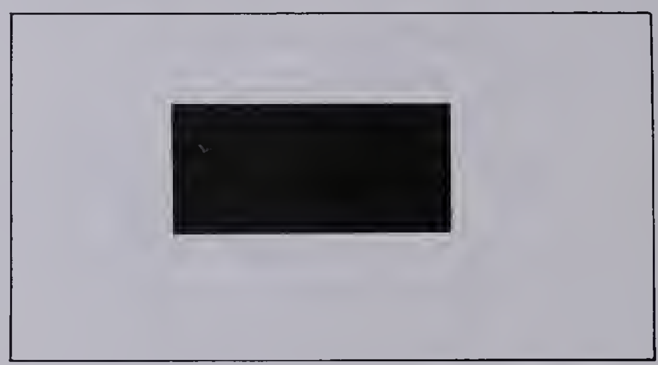
1. Be sure your thermometer covers the range of expected temperatures. Do not use an oral thermometer to measure the temperature of ice, and do not use a freezer thermometer to measure the temperature of boiling water.
2. Immerse the thermometer bulb in the liquid to be measured. Do not let the thermometer hit the walls or bottom of the container, or use it to stir the liquid.
3. Watch the mercury or alcohol rise or fall in the thermometer. After it has stopped moving, read and record the temperature.

Mass (balance)

1. Be sure the balance is on a flat, level surface.
2. If the pan is dirty, wipe it with a damp paper towel and dry it.
3. Check to see if the pointer is at zero. If it is not, ask your teacher to show you how to zero the balance.
4. Release the arm, if necessary, so that it swings freely.
5. Put an empty beaker on the pan.
6. Bring the pointer to zero by moving the weights along the beams. Start with the larger weights and then add the smaller weights until the pointer is at center position. The sum of the positions of the weights used is the mass of the beaker.
7. Record the mass of the empty beaker.
8. Add the mass of weights to the beam that is equal to the mass of substance you wish to measure. For example, assume you want to add 9 g of water to the beaker. Add 9 g of weights to the beams.
9. Slowly pour cold water into the beaker until the pointer swings to center position. This indicates that you have added the 9 g of water.

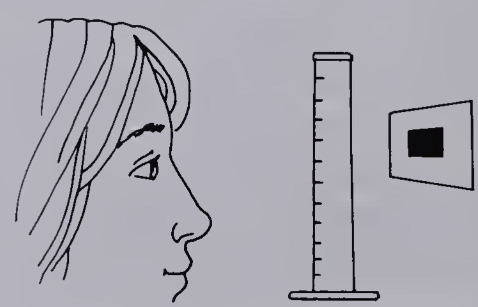
Volume (graduated cylinder)

1. Pour the desired amount of liquid into a graduated cylinder.
2. Holding the cylinder at eye level, read the position of the bottom of the Meniscus (curved surface of the liquid). The reading is the volume of the liquid.
3. If you wish, make a meniscus-reading aid with white paper and a marker, as illustrated.



(actual size)

4. Hold the cylinder at eye level and the aid about 2 cm behind the meniscus. Moving the aid up and down, look for a sharp definition of the bottom of the meniscus.

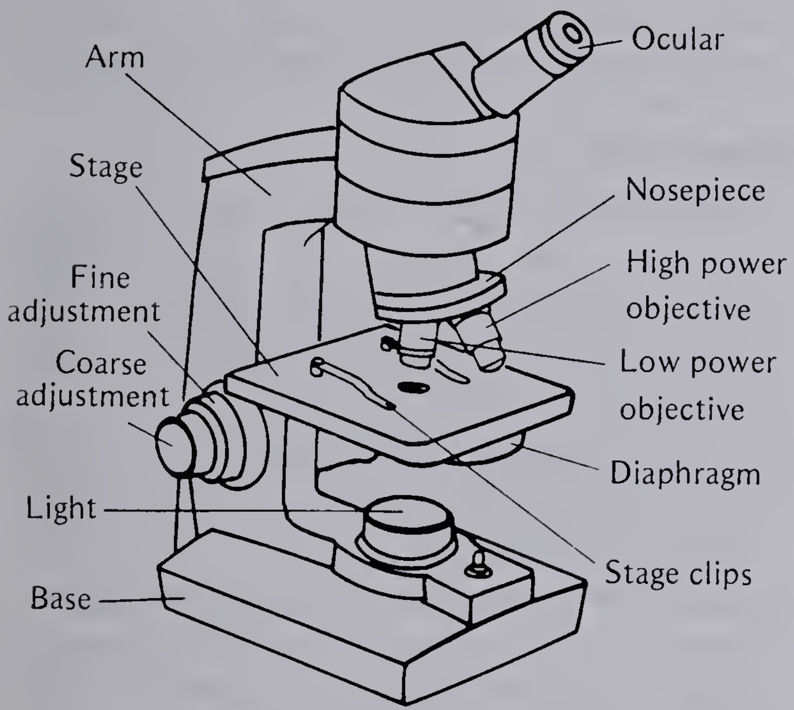


Length (ruler)

1. Lay the ruler along the object to be measured.
2. If the object falls between two marks on the ruler, read the length to the nearest mark.

Name ______________________________ Date ____________

Laboratory Skill 5
Using the Compound Microscope



Lighting

1. Adjust the light so that you see a uniformly bright field of view through the lenses. Looking through the ocular, tilt the mirror to project the maximum amount of light through the lenses. Or, if your microscope has a substage light, turn that on.
2. If the light is too bright, close down the diaphragm until the light is comfortable.
3. If dirt is in the field, clean the lenses with lens paper.

Focusing

1. Place a slide with a specimen on the stage and secure it with the stage clips. Check the objective—you should start focusing with the low power lens.
2. Watching from the side, use the coarse adjustment knob to bring the objective lens very close to, but not touching, the specimen.
3. Next, looking through the ocular, raise the objective with the coarse adjustment knob until the specimen is approximately focused. Do not lower the lens or raise the stage while looking through the ocular—you can easily break the slide or the lens.
4. Bring the specimen into sharp focus with the fine adjustment knob.
5. Adjust the diaphragm to give contrast and detail.
6. If you wish, switch to the high power objective and focus with the fine adjustment knob.

Wrapping Up

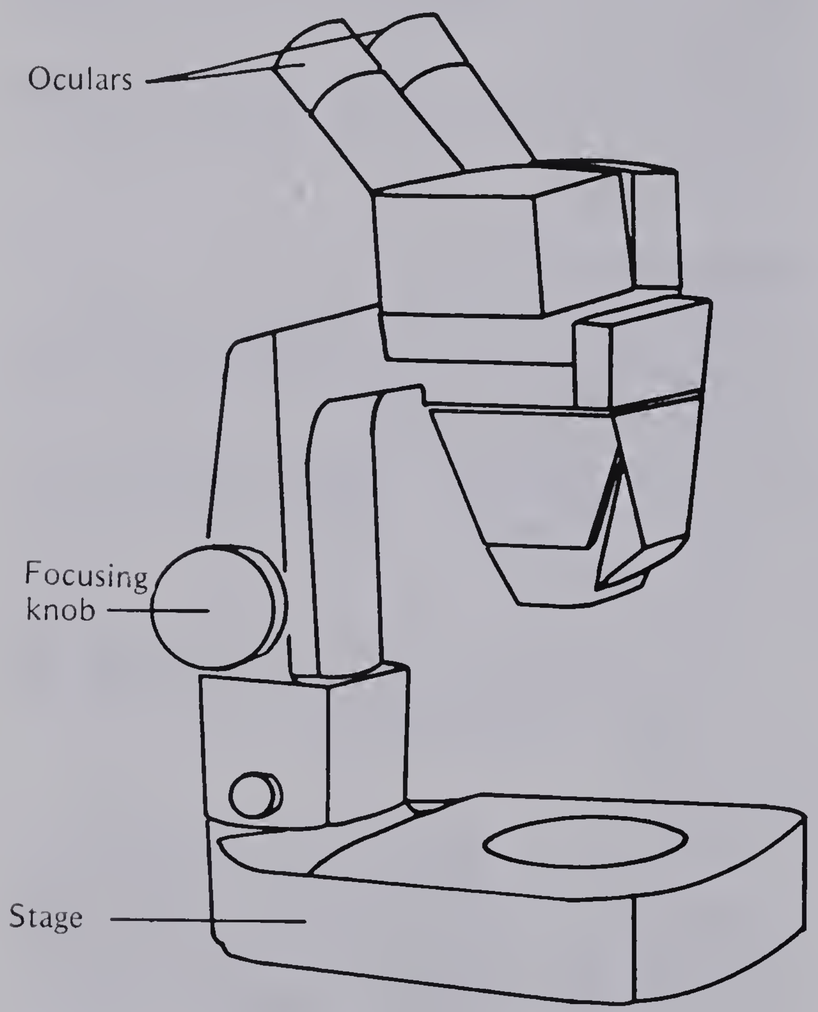
1. When you have finished your observations, remove the slide and rinse and dry it with a paper towel.
2. Put the low power objective in place, and switch off the light (or turn the mirror upside-down).
3. Put the microscope away, holding the arm with one hand and supporting the base with the other hand.

Cautions

1. Be sure that the stage is horizontal, so that specimen stays in place on the slide.
2. When coarse focusing, always move the lens in a direction away from the stage.
3. Use only lens paper for cleaning the lenses.
4. Immediately wipe up any water spilled on the stage or the bottom of the slide, using a paper towel.
5. If you replace a slide, repeat the procedure for focusing from the beginning.
6. Do not leave an electric light turned on when there is a specimen on the stage unless you are viewing the specimen.

Name ______________________________ Date ____________

Laboratory Skill 6
Using the Dissecting Miscroscope



Characteristics

1. The dissecting microscope has lower magnifying power than the compound microscope. The magnifying power is usually between 10x and 50x.
2. The field of view is larger than that of a compound microscope. This means you can see more of the object, but in less detail.
3. Many dissecting microscopes have two barrels, two oculars, and two objective lenses. This gives a stereoscopic (three-dimensional) effect. You can spread the barrels apart to comfortably fix your eyes. Also, you can focus each set of lenses separately to meet the different needs of each eye.
4. Because the magnification is lower than that of the compound microscope, only coarse focusing is needed.
5. The specimen is usually lit by reflected, rather than transmitted, light.
6. The position and direction of movement of a specimen viewed through the lenses is the same as that on the stage. This is in contrast to the compound microscope, which reverses position and direction.

Operation

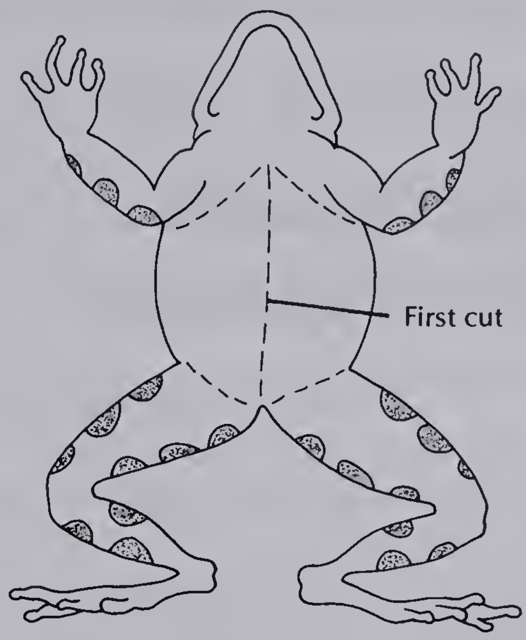
1. Put a slide and specimen, without a coverslip, on the stage. Or, if the specimen must be kept wet, put it in water or saline solution in a shallow container and put the container on the stage.
2. Looking through the oculars with both eyes, spread the barrels to the width most comfortable for your eyes.
3. Using the focusing knob, focus the microscope while viewing through the *nonadjustable* ocular (close the opposite eye). You should have a sharp, three-dimensional view of the specimen.
4. Looking through the *adjustable* ocular (close the opposite eye), fine turn the ocular knob to suit your vision.

Measurement

1. View a ruler through the microscope at low power. The length of the ruler that is visible tells you the diameter of the field of view.
2. If your microscope has more than one power, repeat step 1, using other powers.
3. While viewing an object, you can estimate its size by comparing it with the diameter of the field. For example, if the diameter is 4 mm, and the object covers half the field, the object is about 2 mm in size.

Name ______________________ Date ____________

Laboratory Skill 7
Dissecting Animal Specimens



Although the details of anatomy differ among the animals you will dissect, the general dissection technique is the same for all. Throughout the procedure, try to determine the functions of the body parts you are observing.

The following descriptive terms will be used. *Dorsal* (back) side, *ventral* (under) side, *anterior* (head) end, and *posterior* (tail) end locate positions on the animal. *Longitudinal* (lengthwise) and *lateral* (to the side) are cutting directions. The terms can also describe body parts, such as longitudinal muscles.

You will begin by examining the animal's external anatomy: general shape, appendages, sense organs, and any special features. Note whether the animal is a male or female.

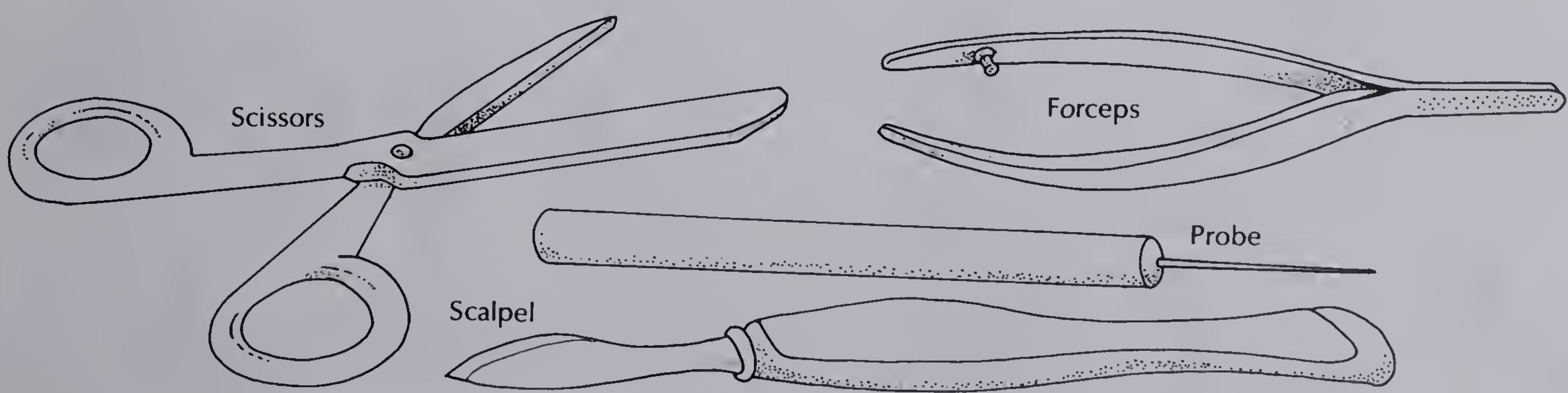
To prepare for dissection, place the animal in the dissecting pan in the position indicated and pin it to the wax in the pan. Cut with a scalpel or sharp scissors, following the diagram. Make shallow cuts (unless otherwise directed), so as not to damage underlying tissues or organs. You may have to cut through several layers: skin, fat, muscle, or others. Pin back body walls to expose the internal anatomy.

The blood vessels of some specimens might have been injected with a latex dye. Red indicates arteries and blue shows veins.

Identify the visible internal organs without disturbing them, using descriptions and illustrations in the laboratory manual as a guide. Examine all organs of a system (circulatory, respiratory, digestive, reproductive, excretory, nervous) to understand how they work together. To expose the entire internal antomy, you will have to dissect out some organs. Proceed as directed in the manual.

When examining the internal structures, use the forceps and dissecting probe. The forceps can be used to lift and trace blood vessels and organs. With the probe, you can investigate cavities and scrape tissue away gradually.

As you remove organs, keep them in the dissecting pan. No part of the specimen should be put in a wastebasket. When the dissection is completed, wrap the organs and specimen in paper towels and dispose of it as directed by your teacher.



Name ______________________________ Date ______________

Laboratory Skill 8
Working with Microorganisms

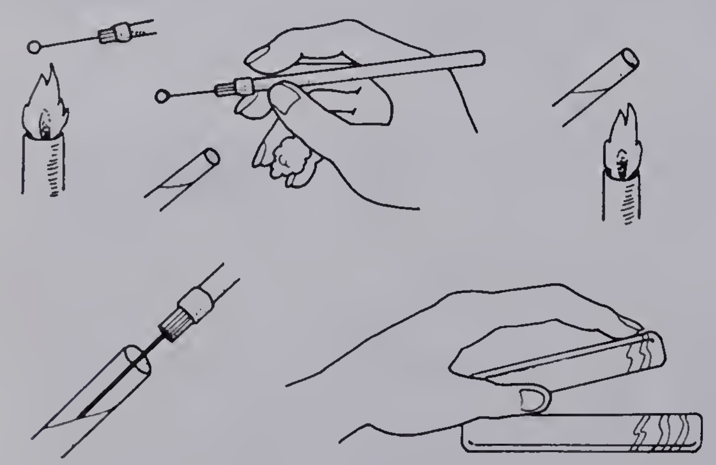
The biology laboratory teems with stray bacteria and fungal spores. Unless you are careful, they will settle on your cultures and contaminate them. Similarly, if you release the microorganisms you are culturing into the laboratory, they can contaminate other cultures. One frequently used technique of preparing a pure culture plate is the streak-plate method.

While preparing a streak plate—or doing any work with microorganisms—you should follow what bacteriologists call *sterile technique*.

Sterile Technique

Practice this technique with tubes of water and empty petri dishes before using it to prepare culture plates.

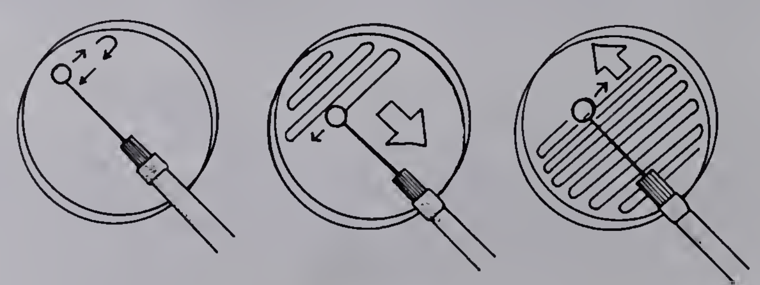
1. With a germicide, sponge off your work surface. If possible, cover the surface with a piece of sterile cheesecloth.
2. Assemble your equipment, which will probably include: cultures in a rack, inoculating loop, covered petri dishes containing sterile agar, wax pencil, pencil, Bunsen burner, slides, and pipettes.
3. Work quickly and carefully. Do not talk or make unnecessary movements, which would stir up the air. Keep your mouth closed and breathe through your nose, using a mask if it is available.



Sterile transfer

Making a Streak Plate

1. Turn on the gas part-way in the burner, and light it with a striker.
2. Hold the inoculating loop between the thumb and first two fingers of your right hand throughout this procedure.
3. Flame the inoculating loop until it is red-hot, then cool it in the air for a few seconds so that it does not kill the organisms.
4. Hold the culture tube in your left hand. Using the little finger of your right hand, remove the cotton plug. Hold it between your fourth and fifth fingers.
5. Flame the lip of the culture tube.
6. Dip the loop into the culture and withdraw it. Do not let it touch anything.
7. Flame the lip of the culture tube again, replace the plug, and put the tube in the rack.
8. Lift the cover of a petri dish and keep it in your left hand. Touch the loop to the sterile agar, releasing a drop of the culture.
9. Use the loop to streak the drop of culture over the agar surface, as illustrated. Cover the petri dish.
10. Flame the loop again and replace it in its holder.

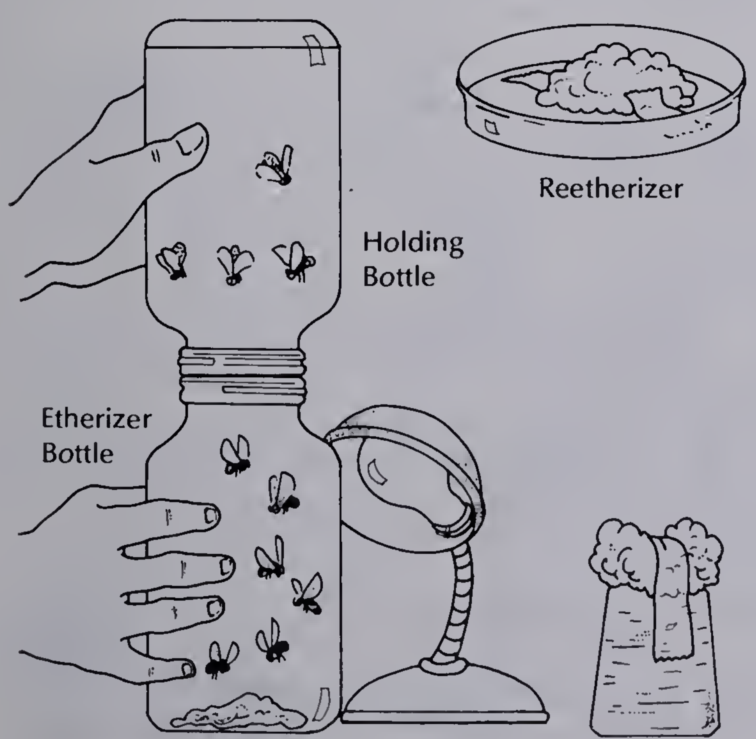


Name ______________________ Date ____________

Laboratory Skill 9
Working with *Drosophila*

Anesthetizing *Drosophila*

1. Turn on a desk lamp in the work area. If possible, turn off other room lights.
2. Gently shake the flies to the bottom of the holding bottle.
3. Remove the stoppers from the etherizer and the holding bottle. Immediately place the lips of the bottles together.
4. Keeping the bottles together, carefully position the etherizer underneath.
5. Hold the bottom of the etherizer near the light. The flies will fly toward the light.
6. When all the flies are in the etherizer, quickly insert the cork.
7. When the flies become anesthetized, they will stop moving. *Caution:* If you leave the flies in the etherizer too long, they will die.

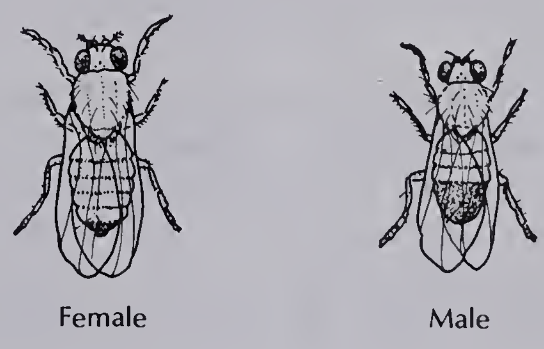


8. Gently shake the anesthetized flies out onto a file card to be examined.

If the flies awaken while you are examining them, anesthetize them again. Place one drop of ether on the cotton in the reetherizer and invert it over the flies until they stop moving.

Observing *Drosophila*

1. Never touch the fragile flies with your fingers. To move them, use a camel's hair brush.
2. Use a hand lens or disecting microscope to observe characteristics such as eye color, wing size, body color, and sex.
3. To determine the sex of the adult flies, look for the following characteristics: Female: larger body size, tip of abdomen pointed. Male: smaller body size; tip of abdomen rounded, with brown spot on ventral side; dark bands across dorsal side.



4. Flies that have just emerged from the pupal stage are harder to sex. Look for the shape of the abdomen tip.
5. Separate the males from the females by brushing them to opposite sides of the card.
6. When you finish examining the flies, transfer them to a culture bottle. Place the bottle on its side and gently brush the desired sex and number of flies into the bottle. Insert the stopper. Leave the bottle on its side until the flies revive, so they will not get stuck in the medium.
7. Dispose of unwanted flies by placing them in the morgue.

Name ______________________ Date ____________

Laboratory Skill 10
Making a Field Trip

The key to a successful field trip is preparation. Before going into the field, you need to know what data you are to collect, what methods you will use, and what to take with you. Your teacher will coordinate the planning.

Make a list of the things you will take, and check the list just before leaving. For a day field trip outside your own school grounds, you will need sturdy comfortable shoes or boots with nonslip soles, layers of clothing appropriate for weather changes, a small day pack, and possibly a container of water.

For longer trips or trips into rugged areas, add items such as suntan lotion, insect repellent, matches, and a first aid kit. A book about backpacking will provide helpful suggestions.

In addition to personal equipment, you will take whatever is necessary for the field work. A small notebook and pen are essential for recording your observations. If you plan to take photos, be sure you have the appropriate film and lenses for the subjects. Before the trip, decide what team and class equipment is necessary. Duplication should be avoided where possible.

Usually the entire class will have the same general task, such as observing the stages in succession from the center of a pond to the surrounding trees. Everyone should prepare by becoming familiar with the common plants in the area and by understanding succession. The teacher will probably have you review measurement and mapping techniques, and you will need a standard procedure for recording data.

Several teams may be assigned different jobs. For example, one team (in a boat or wearing hipboots) would study the center of the pond. Another might study the emerging plants around the pond's edge. A third team could observe the shore, and a fourth the woods.

Team members can divide the work. One person can take notes, another can look up organisms in field guides, another can shoot photographs, and so on. When the teams return to the classroom, they can combine their findings for a complete picture of the area.

Successful fieldwork depends on the cooperation of everyone. Working with a team extends your range in the field. And a team, of course, is only as good as its individual members.

Name ______________________________ Date ____________

Problem Solving 1
Murder at the Zoo

Famous detective Inspector Watson, with his trusted companion Holmes, was visiting a zoo on one of his rare holidays. Watson's orderly mind (which never went on vacation) had been at work during their visit, and as they roamed about he often consulted reference books and a map of the zoo.

Like many modern zoos, this one contained some habitat groupings, such as Area A, the "northwoods" area. The animals and plants in Area A were not necessarily related to each other. What they had in common was their natural habitat—in this case a coniferous forest like those found in northern Michigan and much of Canada. Visitors could see moose, bears, and other animals in their natural surroundings rather than in cages. In addition, all sorts of organisms—not just animals—could be seen there.

Because the zoo originally had been set up with caged animals grouped according to the traditional classification system, there were areas, such as Area K, which contained nothing but mammals. Certain mammals could also be found in some of the habitat groupings as well.

Mr. Moriarity, the zoo director, had stopped to chat with Holmes and Watson as they were leaving. He explained that he was unhappy with the older areas of the zoo, but was seriously hampered by a chronic lack of funds. As money became available, he was gradually setting up new habitat areas and moving the animals into them. In the meantime, the zoo was a rather strange mixture of natural communities and groups of animals in cages or aquariums.

"It's very difficult for some of our visitors," Moriarity sighed. "Whenever you wish to find an organism, you must consult the map. If the organism is specifically listed in a habitat grouping, that is where you can find it. If not, you have to look in the most appropriate classification area. An annelid worm, say, is an invertebrate; but it is kept not with the invertebrates in Area L, but in Area I, the crustacean and annelid zoo. It all makes sense if you know a little about classification, but if you don't, our zoo can be very confusing."

Holmes's forehead puckered. "Well, then, where would I go to see a kangaroo? You don't have an Australian area—would I look in Area K, the mammals?"

"As any fool knows," Watson said, "a kangaroo is a marsupial. Certainly the kangaroos must be in Area H."

Moriarity was beginning, "Quite right..." when a pale, agitated curator ran up to them. "Oh, Mr. Moriarity, a dreadful deed has been perpetrated here! Lord Richard Randall, the wealthy science author who has donated so generously to the zoo has been murdered!"

Watson asked, "When and where did the murder take place?"

"It looks as if he was killed an hour or two ago—his body was just found behind a tool shed. He was near an animal that has stinging cells, in Area..."

"Yes, of course," Watson interrupted. "Mr. Moriarity, time is of the essence. Please call in the police and have them round up all persons in the zoo who might have had any reason to kill Lord Randall. I will interview them and attempt to find out which of them was the murderer."

Name ______________________________ Date ______________

Problem Solving 1, page 2

Moriarity rushed to a telephone, and before long a group of suspects was brought to the director's office, where Watson and Holmes waited with the map and a biology textbook in hand.

Watson explained that he needed to have each suspect make a statement about his or her whereabouts at the time of the murder (now known to be 11:20 a.m.), a statement that could be supported by a witness.

"To give you an example," he said, "at 11:20 I was in Area K watching a hippopotamus, and Holmes can verify that statement."

The director added, "Similarly, at that time one of the curators and I were working together near the members of the invertebrate phylum most closely related to the chordates, and if the curator were a suspect, I could verify her statement."

The suspects proceeded to give Watson their statements and the names of witnesses who could verify them. Eventually Watson had the following list:

Suspect	*Location at 11:20*	*Area*
Miss LaRue, *glamorous companion of Lord R*	Near a turtle	________
Lady Randall, *Lord R's jealous wife*	Near an egg-laying mammal	________
Mr. Moriarity, *zoo director*	Near members of the invertebrate phylum most closely related to the chordates	________
Dr. Stone, *a zoo curator*	Near a gymnosperm	________
Mr. Cratchit, *Lord R's clerk*	Near an opossum	________
Lord R's chauffeur	Near a spruce	________
Lord R's parlor maid	Near a *Plasmodium*	________
"Crazy Mary"	Near an arachnid	________
Professor Moon, *director of another zoo*	Near a non-diving bird	________
The Duke of Newton, *who loves Lady R*	Near an ape	________
Lord R's older son	Near a bryophyte	________
Lord R's older daughter	Near a bat	________
Lord R's younger son	Near a mollusk	________
Lord R's younger daughter	Near an organism that alternates between a unicellular, ameboid stage and a multinucleate stage	________
Mr. Noroian, *Lord R's editor*	Near a salamander	________
Miss Adams, *Lord R's agent*	Near the non-planarian platyhelminths	________
Mr. Addison, *Lord R's publisher*	Near a land-living arthropod	________
Mrs. Windsor, *a rival author*	Not near an animal with gills (areas *not* in)	________

Name ______________________________ Date ____________

Problem Solving 1, page 3

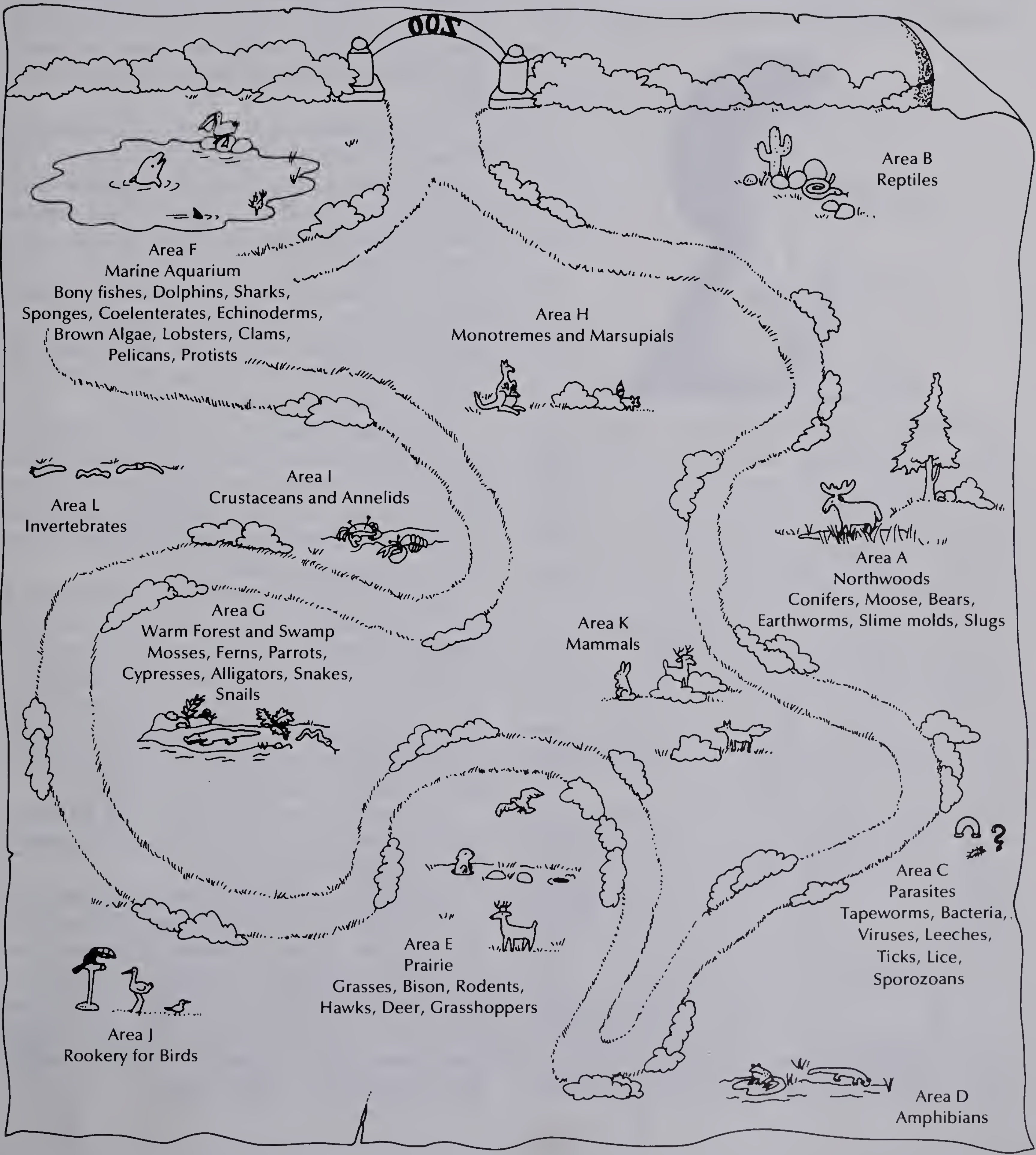
Using Watson's list, the map, and the classification system given in your textbook, figure out where each suspect was at 11:20 and fill in the blanks in the list. Then answer the following questions:

Where was Lord Randall murdered?

____

Who was the murderer?

____



Name ______________________________ Date ______________

Problem Solving 2
The Case of the Hooded Murderer

Lord Robert Lancaster's body—with a long dagger protruding from the chest—lay sprawled in his library. A draft of Lord Robert's new will, which would have disinherited his family and left his vast fortune to charity, was still on his desk. The will was not signed and so his nieces and nephews would inherit his money and property.

The Lancasters were a large, wealthy British family. Lord Robert's brothers and sisters had all died before him, and he never married. But he was scarcely alone. His twelve nieces and nephews had moved into the houses on the family estate.

One of the police officers who came to investigate the murder was Inspector Watson, a shrewd sleuth who had once planned to be a biologist. His special interest was genetics, and he was particularly interested in the Lancaster murder because of certain patterns of inherited traits in the family.

As Watson explained to Holmes, "Old Lord Peter (Lord Robert's father) is shown in that portrait over the fireplace. As a young man he had bright red hair. His wife, Violet, was a brunette. Half their children, including the late Lord Robert, had red hair; the others were brunettes. As only a recessive pair of genes (aa) will produce red hair, each of Lord Peter's children received an a gene from him."

Watson went on, "We know Lady Violet had A genes because she was a brunette, and even one A gene will produce brown hair. But Lady Violet must have been heterozygous (Aa) because half her children had red hair."

In questioning the family and servants, Inspector Watson found a witness to the murder, a maid who had heard a groan from the library. Afraid to go in, she had peeped through the keyhole and seen someone in a long, hooded cape. "I couldn't even tell whether it was a man or a woman, sir. But I did see a bit of red hair sticking out from under the hood. The person had a nervous habit of pulling on one ear lobe, which I noticed was not an attached lobe."

"Aha!" said Watson. "Ear lobes, also, owe their attachment to one pair of genes. A person who is homozygous dominant (EE) or heterozygous (Ee) has free ear lobes, and someone who is homozygous recessive (ee) has attached ear lobes."

The inspector began drawing up a chart of the Lancaster family, using portraits and family albums. Some information was not available, but he learned three important pieces of information. First, old Lord Peter Lancaster had free ear lobes. Second, Lady Violet had attached ear lobes. Third, some of their children had attached ear lobes.

By a strange coincidence, Lord Robert's brothers and sisters had all married persons having attached ear lobes.

Unfortunately, no pictures of the suspects were available, and Inspector Watson had not yet met them in person. The servants could not remember whether the suspects had free or attached ear lobes, but of course they knew which had red hair and which were brunettes. Inspector Watson added that information to the chart.

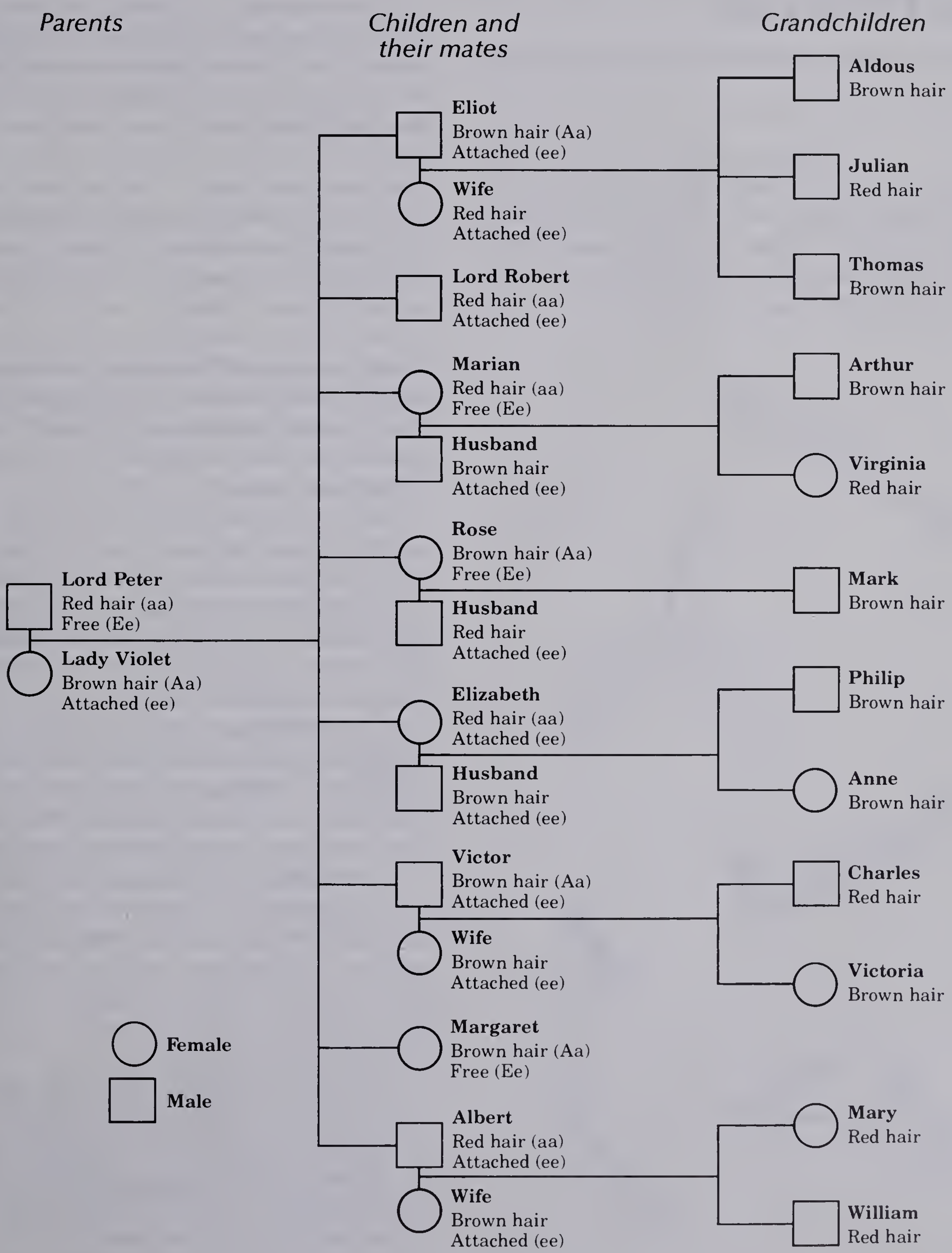
Name ______________________ Date __________

Problem Solving 2, page 2

Below is the chart Inspector Watson made up. Using the information in the chart, you should be able to determine the murderer's identity.

Who murdered Lord Robert? ______________________

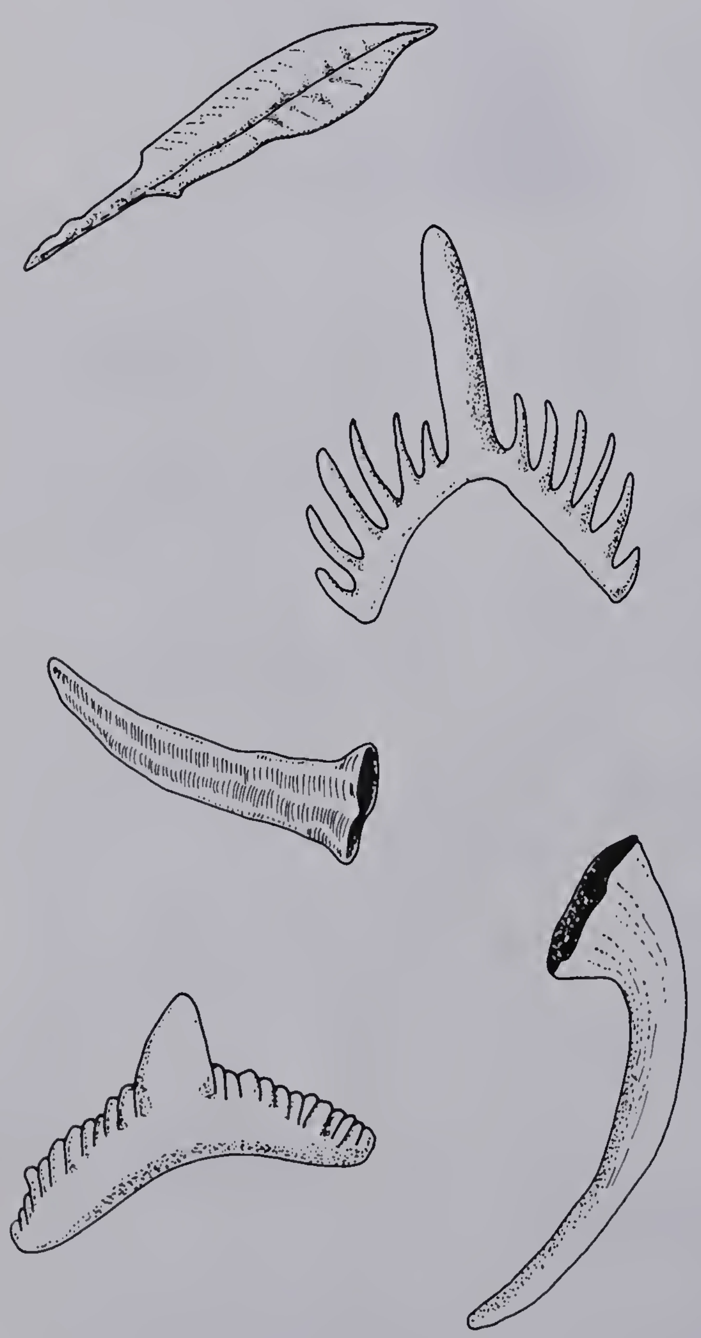
Inspector Watson's Chart



Name ______________________________ Date ______________

Problem Solving 3
In the Teeth of the Evidence

For more than a hundred years, biologists have argued about the origin of the structures pictured below, called conodonts. (They were given that name because they are cone-shaped and toothlike.)



Conodonts have been found in many parts of the world in fossil rocks that are millions of years old. Conodonts are rather familiar, common objects to geologists and people who drill for oil or examine rocks for other reasons.

But no one knows exactly what they are. What is known is that conodonts contain protein, and so they must have been formed in living organisms. They also contain a chemical that is not found in plants.

What are the Clues? You are invited to try your hand at being a science detective, using the clues given below. Chapter 2 and the classification appendix at the end of your *Addison-Wesley Biology* textbook may be consulted for information on each of the major animal and plant phyla. After reviewing the clues, formulate a hypothesis about what kind of organism conodonts were, or what organisms might have contained conodont structures.

The clues listed below consist of all the pertinent information known about conodonts thus far discovered and studied.

1. Conodonts are made partly of apatite, a phosphate-containing material found in vertebrate teeth and in the digestive tracts of some invertebrates.
2. No backbone has ever been found associated with conodonts. All members of the Vertebrate Subphylum have backbones, and backbones are common fossils because bone does not decay rapidly as does soft tissue.
3. Microscopic examination of conodonts show that they grew larger by the addition of new layers of apatite to their outer surfaces. Vertebrate teeth do not grow in this way. This growth pattern is usually found in structures inside an organism, surrounded by soft tissue.
4. No conodont found has a pulp cavity; vertebrate teeth have pulp cavities.
5. When conodonts are found in pairs, they seem to be left-right pairs like the teeth some worms have; vertebrate teeth are formed as upper-lower pairs.
6. Some conodonts have been found near worm tracks.

Name ______________________________ Date ______________

7. No conodonts have been found in rocks that are less than 200 million years old. Bird and mammal remains are found *only* in rocks that are less than 200 million years old.

8. Conodonts are found in material that settled out of a saltwater environment.

9. Proteins in the conodonts are like the proteins found in invertebrates.

10. As teeth are used for chewing, they are worn down. Teeth used for filtering food are not worn down. Conodonts show no signs of wear.

11. Conodonts look like structures in worm jaws, but are chemically different.

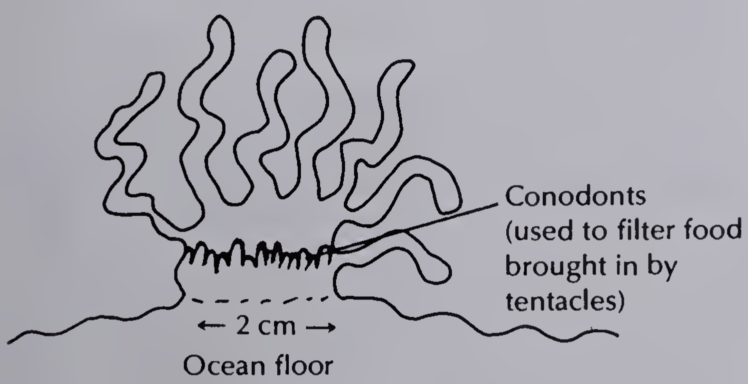
12. Conodonts are 0.1 mm to 5.0 mm long.

Hypothesizing about Conodonts Write your hypothesis about what conodonts were in a way that predicts what the complete animal will look like if an entire "conodont animal" is ever found. Here is an example:

Hypothesis: *If* the conodont animal was a coelenterate, *then* it had tentacles with stinging cells, its body had two cell layers, and its digestive tract had only one opening.

A hypothesis stated in this way can be proved wrong, or *falsified*. For example, if someone found part of a conodont animal and could prove that its digestive tract had two openings, your hypothesis would be falsified. You would know then that the animal was not a coelenterate.

After formulating a hypothesis, make a rough sketch of a conodont that incorporates the features mentioned in the hypothesis:



Now it is your turn. Use your imagination!

Hypothesis:

____

____

____

____

Sketch of a "conodont animal:"

Name ______________________________ Date ____________

Problem Solving 4
The Utopia Islands

In this exercise you are given a chance to travel back in time and observe populations of flies inhabiting ancient islands.

About 6 million years ago, volcanic eruptions resulted in the formation of many islands in the Pacific Ocean. Two such islands, Utopia Major and Utopia Minor, were formed near the Tropic of Cancer. Refer to the map of the islands on page 4 while you work through this exercise.

1. The first flies to colonize Utopia Major were blown in by a strong wind from a continent to the northwest. They probably would have been given a name such as *Icarus alboptica* if a biologist had been there to name them, as they had large white eyes (WW). Their wings were typical wild-type dipteran wings, with no special pattern. *Icarus* flies could tolerate a range in temperature of 15° to 30° C.
2. The warm, balmy weather and the moist surroundings provided an ideal environment for the flies, and they spread throughout Utopia Major, where there were no serious barriers to their dispersal.

At this point, your information about *Icarus* might be summarized as follows:

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
Utopia Major	I. alb-optica or species 1	A-L	100% white	15-30°C	100% wild-type

3. After the occurrence of a mutation at the locus for eye color, some red-eyed flies (ww) appeared in the population. The additional pigment enabled those flies to see better than the white-eyes flies, but at that time better vision did not give them a selective advantage. Hundreds of years passed.
4. The volcano on Utopia Major erupted, blackening the sky for several days. Of the adult flies, only those with the best vision survived. Before the sky became clear again, a few of those flies were blown to Utopia Minor and began colonizing it.

Complete Chart 1 to show the situation a month later:

Chart 1

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males

Name ______________________________ Date ____________

Problem Solving 4, page 2

5. More mutations occurred in the flies on Utopia Major. Adults of the mutant variety were more resistant to heat. By hiding beneath certain cacti and other large plants, they could tolerate temperatures as high as 38° C.
6. Over thousands of years the volcano erupted many times. Gradually a high ridge was built up (along the dashed line on the map). The ridge was a permanent barrier between the northwest and southeast parts of the island.
7. A long period of heat and low humidity followed. On Utopia Major, the area marked L became a desert, with the daytime temperature often reaching 35° C or more.

Fill out Chart 2 to show the changes at this point:

Chart 2

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males

8. A new species of birds colonized Utopia Major. The voracious creatures preyed on many insects, including white-eyed flies but not red-eyed flies.
9. Thousands of years passed. It was a period of marked behavioral changes in the flies, and isolated groups developed very different courtship rituals. The climate was favorable during this time, and the rain forest spread up the mountain into areas C, D, I, and J.
10. The forest reached the top of the ridge in many places, and groups of flies that were formerly separated from each other were now free to intermingle. Two different things could happen to the flies that came back together. What are they?

   a.

   b.

Choose *one* of those alternatives and fill out Chart 3:

Chart 3

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males

11. Because of mutations, some of the flies throughout Utopia Major acquired a tougher coating during their pupal stage, enabling them to withstand cold temperature as low as 10° C.
12. An epidemic struck the predatory birds, nearly eliminating them.
13. On Utopia Minor, mutations were also occurring. Owing to a recessive autosomal gene, some males had a new, striped wing pattern that greatly increased their appeal to females during courtship. The females ignored the males with wild-type wings, finding the mutant males irresistible.

Fill out Chart 4 showing any changes that have occurred:

Name ____________________ Date __________

Problem Solving 4, page 3

Chart 4

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males

14. A long period of cold ensued. North of the Tropic of Cancer, the temperature sometimes fell to 12° C.
15. After a series of volcanic eruptions, all life above 3000 m perished.

Fill out Chart 5 to show what species were present before the area was recolonized by weeds, where the species were found, and what their characteristics were:

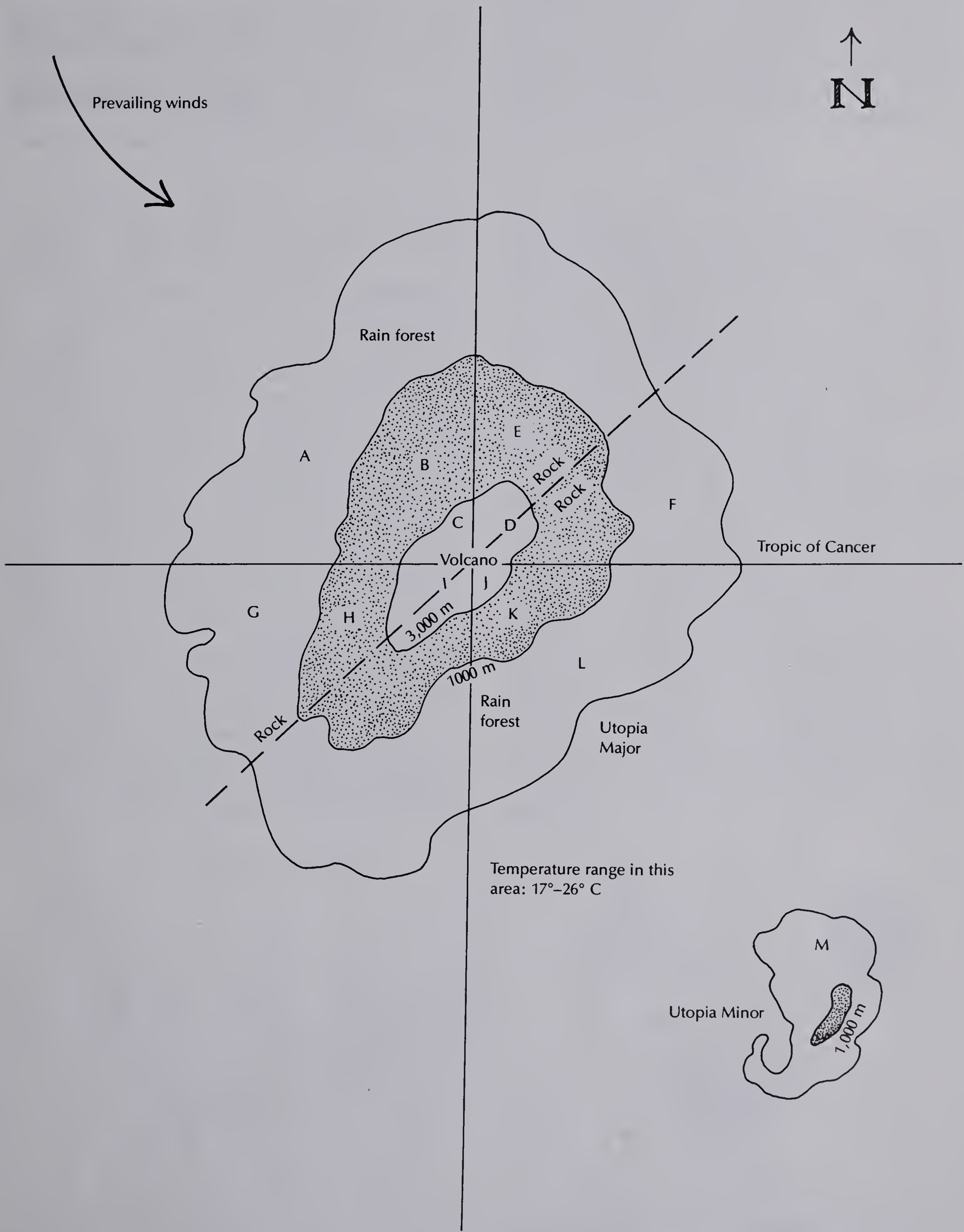
Chart 5

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males

1. Summarize the changes that occurred to the original species of flies over the time period you observed them .

2. Using the theory of natural selection, explain one of the changes that occurred in the flies.

Name ______________________________ Date ______________



Prevailing winds
N
Rain forest
A
B
E
Rock
Rock
C
D
F
Volcano
Tropic of Cancer
I
J
G
H
3,000 m
K
L
1000 m
Rock
Rain
forest
Utopia
Major
Temperature range in this
area: 17°–26° C
M
Utopia Minor
1,000 m

Name ____________________ Date ____________

Taxonomy 1
Introduction

This taxonomy unit gives an overview of organisms living today. It does not include minor groups or extinct groups.

The five-kingdom system of classification was proposed in 1959 by R. H. Whittaker, professor of biology at Cornell University and author of various books and articles on ecology. Until recently, most biologists continued using other classification systems. Whittaker's system has been revived because it reflects the changes in organisms through time better than do other systems.

Lynn Margulis, who teaches biology at Boston University, offers an insight into the origins of complex life forms. According to her theory, eukaryotes contain certain organelles—mitochondria, plastids, and cilia—that were once complete organisms. These organisms resembled modern monerans, such as bacteria and blue-green algae, which lack such organelles themselves.

Margulis hypothesizes that ancient blue-green algae somehow became incorporated into larger host organisms and evolved into plastids. In the same way spiral-shaped bacteria gave rise to cilia, and certain ancient aerobic bacteria evolved to become mitochondria. In each case, the original organism has been modified somewhat to meet the needs of a larger host organism.

Viruses

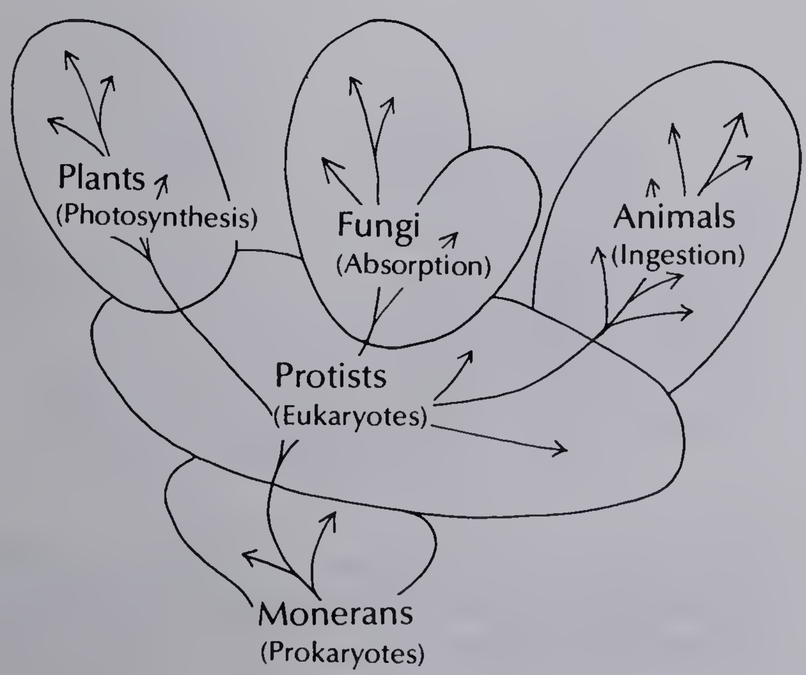
You might expect that cell nuclei are the modern forms of ancient viruses. Quite the contrary—viruses probably arose as fragments of nuclei from other organisms.

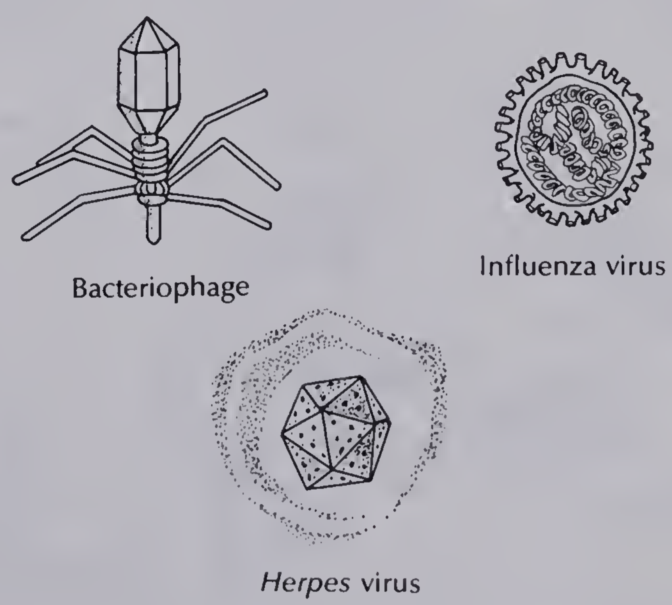
Viruses contain a core of nucleic acid, either DNA or RNA, surrounded by a protein coat. They are able to reproduce only when they have invaded host cells. Once there, they take over the hosts' nuclei, causing the cells to manufacture more viruses.

Viruses are parasitic organisms that infect specific plant, animal, or bacterial hosts. Human diseases caused by viruses include polio, influenza, herpes, smallpox, and measles. It is believed that viruses are responsible for some types of human cancer.

Viruses are found in a variety of shapes. Some have many sides and form polyhedrons; others are symmetrical helixes, such as the influenza virus. Some are enclosed in an envelope made of proteins, lipids, and carbohydrates. The envelope may be spiked, a characteristic used to identify some viruses.

Five-kingdom Classification System





The syringe-like bacteriophage is not enclosed in an envelope.

Name ______________________________ Date ____________

Taxonomy 2
Kingdom Monera

Monerans are the most numerous organisms on earth. The characteristic that distinguishes these microscopic organisms is their lack of a nuclear membrane. For that reason they are called prokaryotes. A moneran's DNA is in a long fiber, not a protein-coated chromosome, as in many eukaryotes. In total, about 3100 species are known.

Unlike the viruses, monerans have cytoplasm. Pigments and enzymes are scattered throughout the cytoplasm of the cells, as monerans have no mitochondria, chloroplasts, or other organelles.

Monerans may live as individual cells or in colonies. The colonial forms may become large, visible masses.

The Moneran Kingdom has two major phyla—the bacteria and the blue-green algae.

PHYLUM SCHIZOPHYTA
(1600 species)

Bacteria are found everywhere, decomposing dead organisms or parasitizing living ones. Thus, they are both helpful and harmful to humans. Some bacteria are aerobic; others are anaerobic.

Bacteria are classified according to their shapes. The three major types of bacteria are the rod-shaped bacilli, round cocci, and spiral-shaped spirilla.

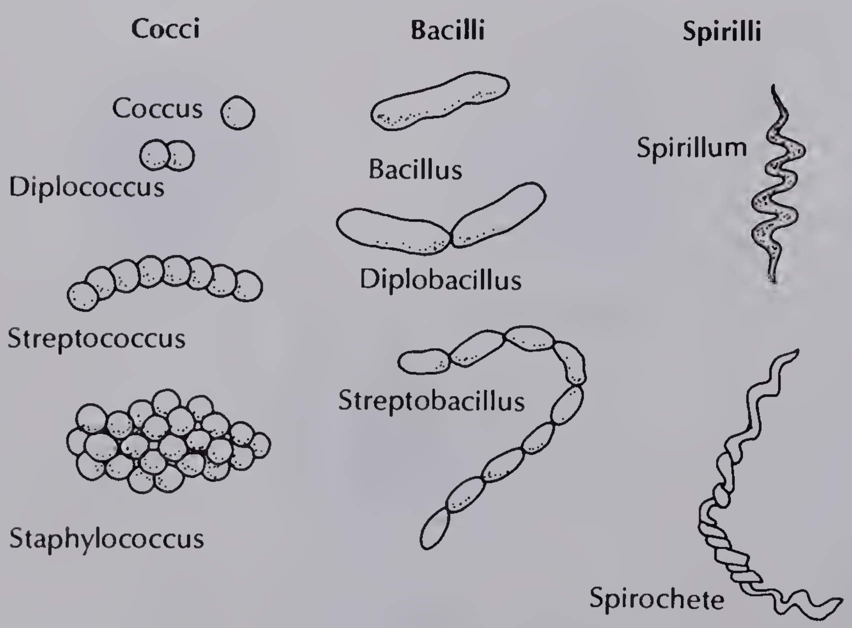
All species reproduce by binary fission, though some undergo other types of asexual reproduction as well. Many species are also capable of exchanging DNA, resulting in genetic recombination.

PHYLUM CYANOPHYTA
(1500 species)

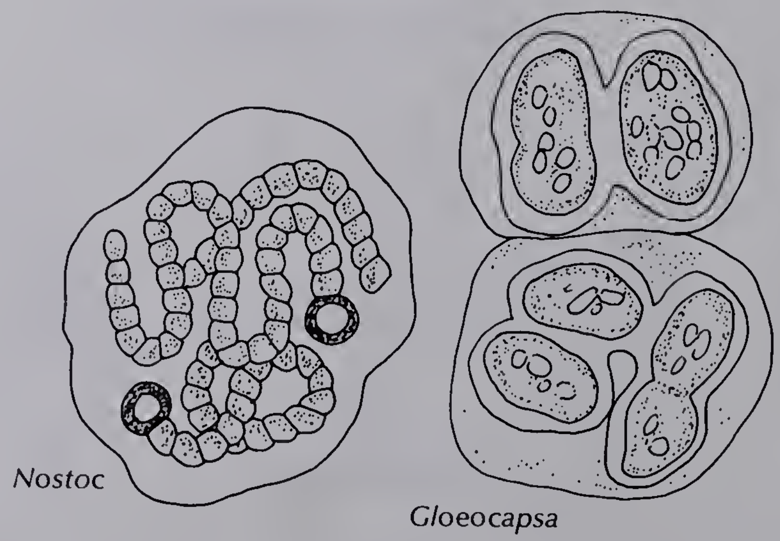
Blue-green algae resemble bacteria in many ways. Unlike the bacteria, however, they contain chlorophyll and make their own food by photosynthesis. Blue-green algae contain other pigments in addition to chlorophyll, including the blue pigment that makes many species appear blue-green. Blue-green algae actually occur in a range of colors, including golden-yellow, brown, red, emerald green, blue, and blue-black.

Blue-green algae live in water, in damp soil, or on damp rocks. Some are even found in extremely hot or cold pools and springs. They play an important role in colonizing barren areas, such as rocks and places destroyed by volcanic eruption.

Blue-green algae reproduce by binary fission.



Bacteria occur most commonly in the form of bacilli.



Gloeocapsa is a unicellular blue-green alga that forms colonies. *Nostoc* colonies are formed of filamentous chains.

Name ______________________________ Date ____________

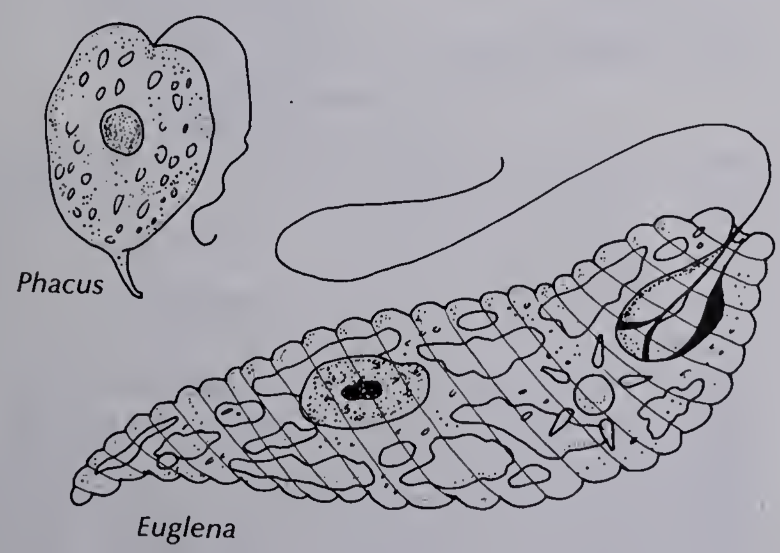
Taxonomy 3
Kingdom Protista

In the five-kingdom system, the smallest eukaryotes are the protists, which number 30 000 species. Protists include all the one-celled, nucleated organisms. Though they are one-celled, that one cell must carry on all the organism's life functions. Thus, a protist is more complex than a more specialized cell of a higher organism.

There is great variety in this group; they are defined partly by not fitting into any other kingdom. Protists include protozoa, which are capable of locomotion by flagella, cilia, or ameboid movements. Plantlike protists include the algae, which contain chlorophyll and produce their own food. Funguslike protists obtain nutrients by absorption and include species that are destructive to some plants. Except for slime molds, protists live in aquatic habitats.

PHYLUM EUGLENOPHYTA
(800 species)

Because most of the species in this group can carry on photosynthesis, they have sometimes been classified as simple plants.



The free-living *Euglena* can photosynthesize. *Phacus* captures and ingests other organisms.

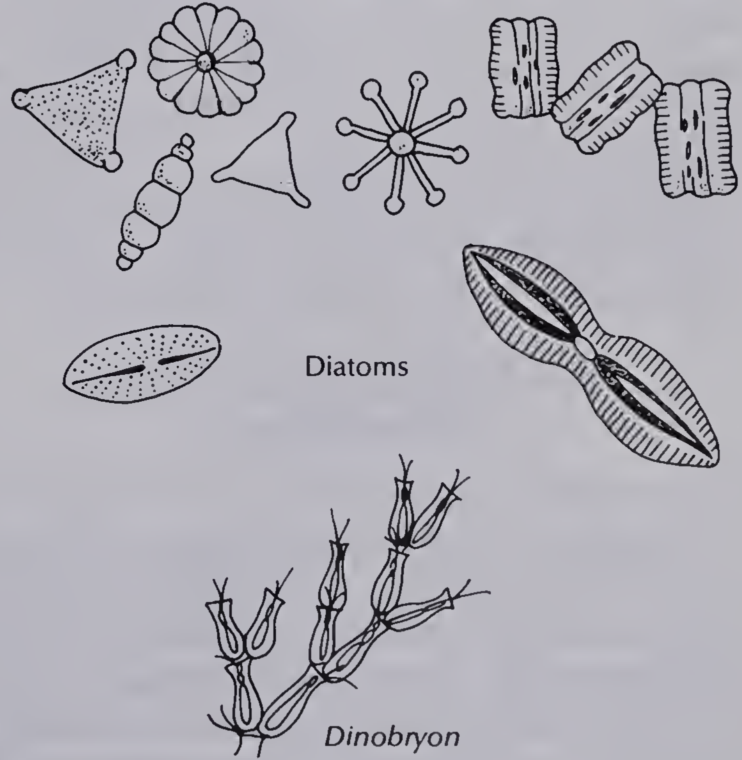
The parasitic species resemble photosynthesizing cells but have no chloroplasts. All these organisms are characterized as having one or two flagella and are known as flagellates. *Euglena* is a freshwater flagellate that in great numbers can be seen as a green scum on the surface of ponds.

PHYLUM CHRYSOPHYTA
(6000 to 1000 species)

These are the golden algae and diatoms. They have cholorphylls *a* and *c* along with another pigment and they store food as a carbohydrate or as large oil droplets.

Class Bacillariophyceae (5000 to 9000 species)
The diatoms have two shells containing silica, that fit together. The diatoms, along with the dinoflagellates, form a large part of the phytoplankton of the ocean's surface.

Class Chrysophyceae (1000 species)
The golden algae have no shells. Others have cell walls with ornamental scales. Their characteristic color is due to the yellow-brown carotenoid fucoxanthin. They store food in the form of oil rather than starch. They may be flagellated, ameboid, or non-moving.



Diatom shells are perforated with minute pores. *Dinobryon*, a golden alga, forms treelike colonies.

Name ______________________ Date ____________

Taxonomy 4
Kingdom Protista

PHYLUM PYRROPHYTA
(1100 species)

The golden-brown algae are sometimes called fire algae. In enormous numbers, they cause the poisonous red tides in oceans. They differ from other algae in their pigments and in the carbohydrate they form. The golden-brown algae have chlorophylls *a* and *c* and make starch. Most have two flagella.

These organisms do not appear to reproduce sexually but have a unique form of mitosis. Dinoflagellates, members of this group, often have oil drops, which help them to float. Some dinoflagellates are luminescent; some have no pigments and feed on minute organisms.

PHYLUM CILIOPHORA
(5000 species)

Larger than amebas, these protists can swim through water by rhythmically beating their numerous hairlike cilia. They use the cilia to capture and eat other organisms. *Paramecium* and *Stentor* are examples of these ciliated protozoans. Classification is based on differences in patterns of cilia on their bodies and in feeding behaviors.

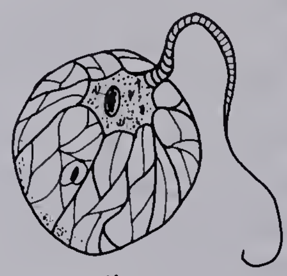
PHYLUM MASTIGOPHORA
(1200 species)

These protists can swim using their whiplike flagella. Their body shapes are more definite than those of amebas. Many are free-living, but some are parasites. *Trypanosoma*, the cause of sleeping sickness, lives as a parasite in insects, some plants, and most vertebrates in Africa without killing their hosts. In humans, however, the disease caused by these protists is often fatal.

PHYLUM SARCODINA
(8000 species)

This phylum includes amebas and their relatives, some of which secrete shells and externally may seem quite different from amebas.

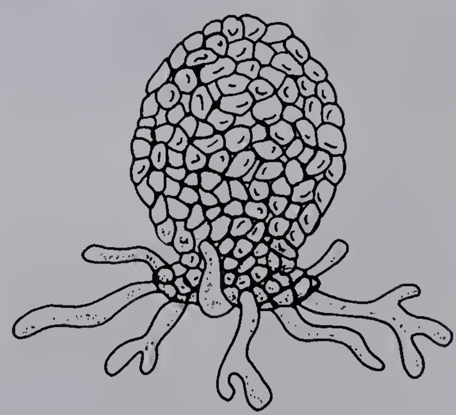
The sarcodines use their pseudopods to move from place to place and to take in food. Food is brought into the cell and surrounded by a saclike membrane; digestive enzymes are then secreted into the sac. Each cell's water balance is controlled by contractile vacuoles that collect water and then release it from the cell surface as necessary.



Noctiluca

Stentor

Trypanosoma



Difflugia

Noctiluca is an ocean-dwelling dinoflagellate that is luminiscent. *Stentor* twirls about using its circle of membranelles, which are actually fused cilia. The flagellum of *Trypanosoma* lines the outside of an undulating membrane. The ameba *Difflugia* surrounds itself with a kind of house made of sand grains cemented together with a sticky secretion.

Name ______________________ Date ____________

Taxonomy 5
Kingdom Protista

Phylum Sarcodina, continued

Foraminifers secrete calcareous shells having minute pores through which they extend pseudopods. The fossil shells of these ameboid protozoa are used by petroleum geologists to identify rock layers and predict where oil and gas can be found.

PHYLUM SPOROZOA
(2000 species)

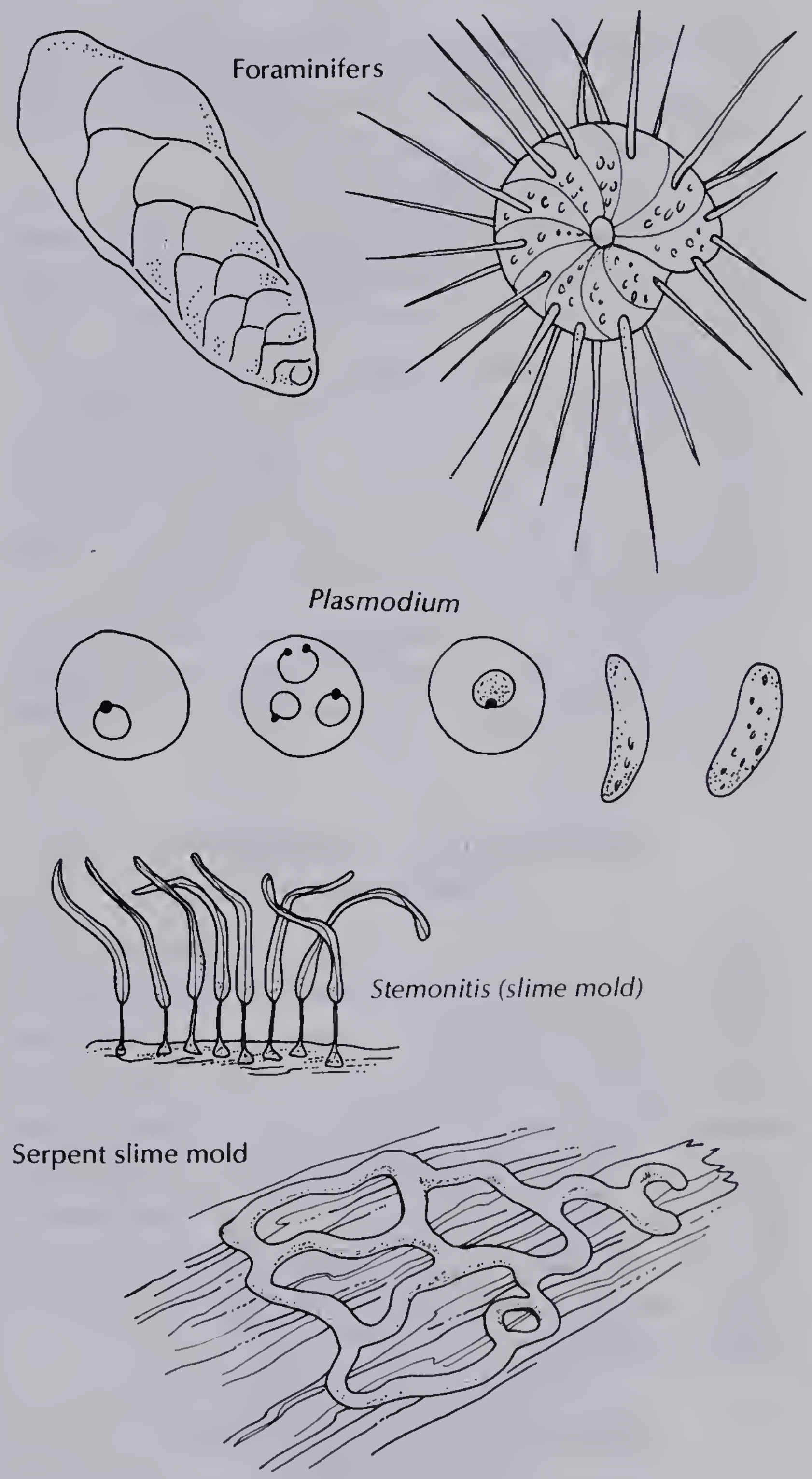
The sporozoans have complicated reproductive cycles, in which some stages are sexual and others are asexual. Spores formed during the asexual stage result from multiple divisions of the nucleus producing a number of offspring at one time.

The sporozoans are parasites. They have no organelles for locomotion but are moved around passively as they are carried in the bloodstreams or other fluids of their hosts. The malarial parasite *Plasmodium* completes its sexual life cycle in the *Anopheles* mosquito; the asexual stages develop inside a human host bitten by an infected mosquito. Both phases involve multiple fissions.

PHYLUM MYXOMYCOTA
(450 species)

Because the slime molds have a complex life cycle, biologists often disagree about how they should be classified. Sometimes they are classified as fungi because during one stage of their life cycle they are stationary and form stalks bearing sporangia.

The protistlike stage of a slime mold is a plasmodium, a large mass of protoplasm having many haploid nuclei. As plasmodia travel they engulf bacteria, yeast, fungal spores, and small particles of plant and animal matter. When food supply and moisture are in short supply the plasmodium differentiates into sporangia that produce spores able to remain dormant for decades. When the spores germinate they produce flagellated cells that form a new plasmodium as they clump together and lose their cell membranes and flagella.



The ameboid protozoan foraminifer secretes a chalky shell. Each variety of *Plasmodium*, the parasite responsible for malaria, passes through a series of life cycle stages. The funguslike form of *Stemonitis* consists of stalks that support sporangia. The serpent slime mold produces cordlike yellow sporangia. Both kinds of slime mold grow on decaying wood.

Name ______________________________ Date ____________

Taxonomy 6
Kingdom Fungi

Like the protists, plants, and animals, fungi are eukaryotes. Some are unicellular, such as the yeast; others are multicellular and include the familiar mushrooms.

Because of their rigid cell walls fungi cannot engulf small organisms; they obtain nutrients by direct absorption into their cells of inorganic and organic materials, secreting digestive enzymes onto a food source. Some fungi are parasitic, such as athletes foot fungus; otherwise, fungi are saprophytes, living on dead and decaying plants or animals or their byproducts.

Fungi have both sexual and asexual reproduction; spores are produced in sporangia. The fungi number about 100 000 species.

PHYLUM ZYGOMYCOTA
(1500 species)

These terrestrial fungi have chitinous cell walls, are multicellular, and produce spores in sporangia. At most times the network of interconnecting tubular cells have no crosswalls, but are like chains of cells that have lost their adjoining walls. This group includes molds, such as black bread mold. The bright colors and powdery textures of many molds are produced by spores shed in large quantities.

PHYLUM ASCOMYCOTA
(30 000 species)

These are known as sac fungi and include yeasts, blue and green molds, and mildew. Edible species include truffles and morels. Some are terrestrial, others are aquatic. Their cell walls are mainly chitin. Most, but not all, are multicellular.

Reproduction may be by budding, which is asexual, or by the formation of saclike asci in sexual reproduction. In general, the cells are separated by perforated crosswalls, allowing materials to flow freely between cells. These fungi are usually found growing on rotting wood or on soil.

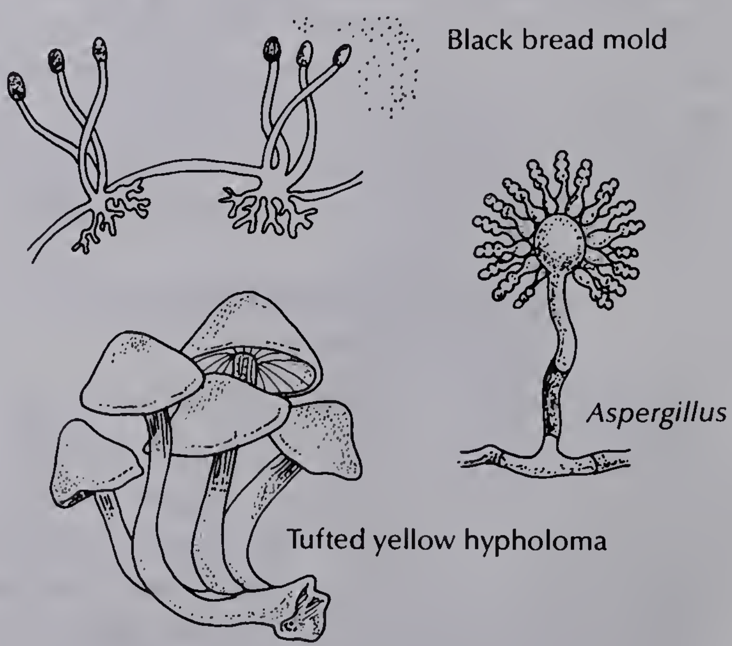
PHYLUM BASIDIOMYCOTA
(25 000 species)

Like the ascomycetes, these terrestrial fungi also have chitinous cell walls and are multicellular. They have crosswalls between cells that develop in three stages; in the second stage the crosswalls are perforated.

They may reproduce asexually, by forming spores, or sexually. Sexual reproduction involves formation of basidia, the club-shaped structures that are the sites of meiosis and spore production. They include the familiar mushrooms and toadstools as well as club fungi.

PHYLUM FUNGI IMPERFECTI
(25 000 species)

These are the fungi whose sexual stages and spore-bearing structures are not yet known. This group includes the molds used in cheeses, the fungus that causes athletes foot, and *Penicillium*, the first source of penicillin.



Black bread mold reproduces asexually by spores; sexual reproduction is by conjugation. Mildew that forms on leather, fruit, and walls is made up of the spores of *Aspergillus*. Tufted yellow hypholoma, a basidiomycete, grows in clusters.

Name ______________________________ Date ____________

Taxonomy 7
Kingdom Plantae

The plants, which include 285 000 species, are primarily multicellular organisms that have cell walls made of cellulose. With few exceptions, they are able to make their own food by photosynthesis; plants have cells containing chloroplasts with chlorophyll *a* and *b*. There is differentiation of tissues and organs in some groups. Reproduction is primarily sexual with the life cycle alternating between gametophyte and sporophyte stages.

PHYLUM CHLOROPHYTA
(7000 species)

These are the most diverse of the algae in form and in life history. Most green algae are aquatic, but they may be found in a variety of habitats including the surface of snow. Some live in salt water; the majority are freshwater organisms.

The green algae may form multicellular filaments or colonies or may be leaflike, but their internal structure is not differentiated into tissues like those of higher plants. The chlorophytes resemble the bryophytes in containing chlorophylls *a* and *b*, in storing food as starch, and in having firm cell walls composed for the most part of cellulose.

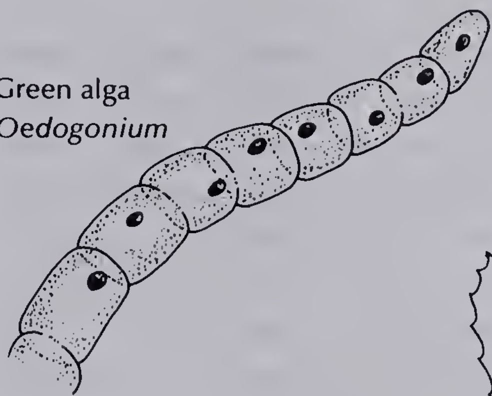
PHYLUM RHODOPHYTA
(4000 species)

The majority of red algae live in salt water. They have no organs for conducting food or water, and no organs for movement. The red algae may have a branched or filamentous structure. Using chlorophyll *a* and other pigments, they make a special type of starch called floridian. Their structure consists of closely packed filaments in a gelatinous material; there is no differentiation into leaves, roots, and stem.

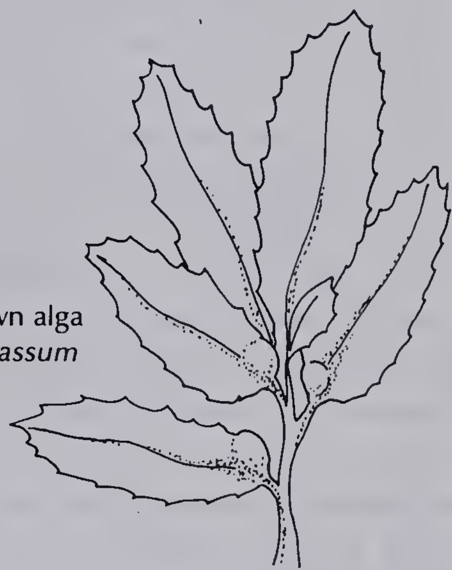
PHYLUM PHAEOPHYTA
(1100 species)

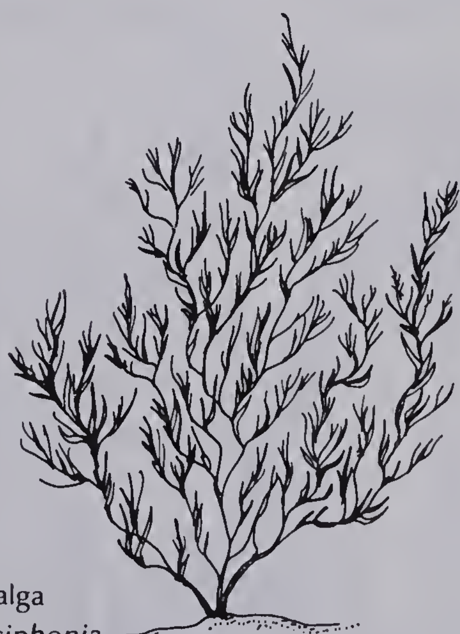
The brown algae are larger than the red algae and are also found in salt water. Many of them have bladders that allow them to float on the water surface; they tend to be stationary. These algae have chlorophylls *a* and *c* as well as a special pigment called fucoxanthin, and they make a carbohydrate called laminarin.

Green alga
Oedogonium



Brown alga
Sargassum





Red alga
Polysiphonia

Green algae have many forms, from single flagellated cells to filaments. The blades of *Sargassum* contain air bladders that aid in floating. The red alga *Polysiphonia* has a many-branched structure.

Name ______________________________ Date ____________

Taxonomy 8
Kingdom Plantae

Phylum Bryophyta
(23 500 species)

Living in a moist but not aquatic habitat, and having little or no conducting tissue, these organisms must remain small so that water can diffuse to all their parts. They have a life cycle that is dominated by the gametophyte. The bryophytes are multicellular plants having chlorophylls *a* and *b* and food reserves in the form of starch.

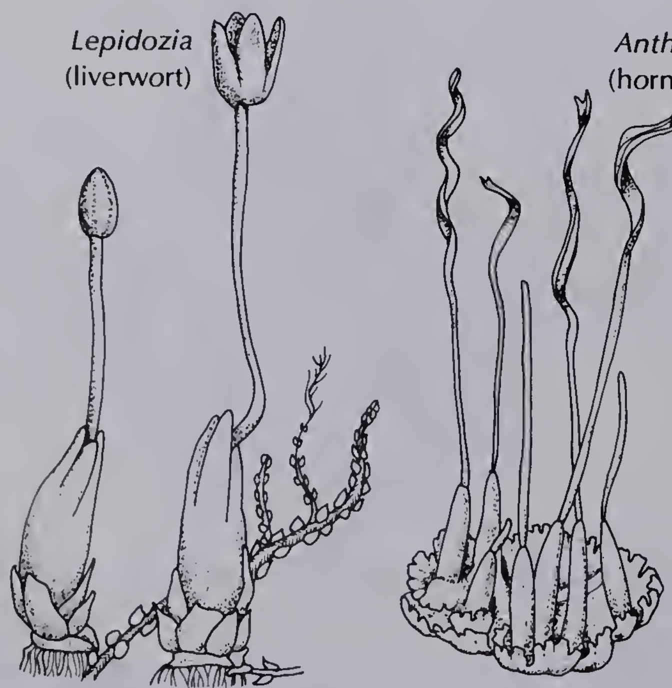
Most bryophytes are attached to a rock or other surfaces on which they grow by rhizoids, which serve only to anchor these plants and do not absorb water or minerals as do true roots. Mosses, liverworts, and hornworts are members of this group.

Class Hepaticae (9000 species)
This class includes the liverworts whose gametophytes are generally leafy; their rhizoids consist of a single cell. Nonleafy liverworts display a wide variety of forms. They are found on moist shaded banks and on other suitable cool moist surfaces such as flower pots.

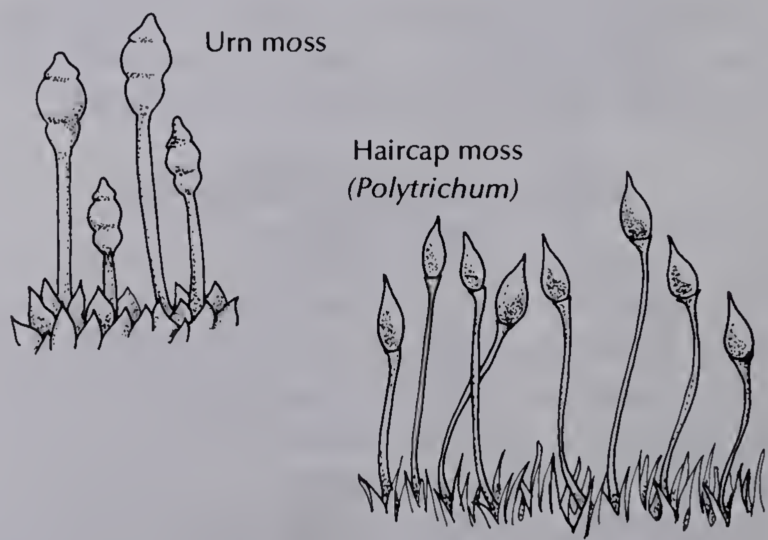
Class Antherocerotae (100 species)
The hornworts, in their gametophyte stage, resemble the leafy liverworts. They resemble algae in having a single large chloroplast in each cell rather than the small, disc-shaped chloroplasts found in other bryophytes and in vascular plants.

The hornworts have mucilage-filled cavities that are inhabited by blue-green algae which supply these plants with nitrogen. The sporophyte in hornworts contains several layers of photosynthetic tissue and consists of a foot and a long cylindrical sporangium.

Class Musci (14 500 species)
In the mosses, the sporophytes, which have stomates, burst open to release thousands of spores. The mossy, leafy generation is the gametophyte, which arises from a filamentous structure known as a protonema. The true mosses are included in this group; an example is *Sphagnum* or peat moss. Other so-called mosses are actually lichen, algae, or vascular plants.



The liverwort *Lepidozia* has a leafy gametophyte. The sporophytes of *Anthoceros*, a hornwort, are attached at their bases to the nonleafy gametophyte.



The "urn" of the urn moss is the spore capsule. At the base of the haircap moss are the female gametophytes.

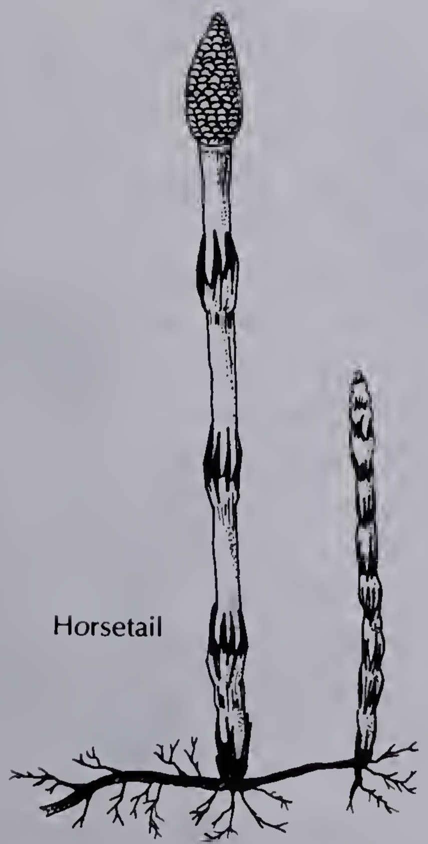
Name ______________________________ Date ____________

Taxonomy 9
Kingdom Plantae

PHYLUM TRACHEOPHYTA
(261 000 species)

These are the first plants to have true leaves, stems, and roots. Their well-developed vascular systems (xylem and phloem tubes) conduct water, minerals, and organic substances. The sporophyte generation is the dominant one, the gametophyte being much reduced. In some species the male gametes are motile, being propelled by many cilia. The tracheophytes are divided into those plants that produce seeds, and those that do not.

Before the seed plants appeared, the sphenopsids and ferns dominated the damp Carboniferous forests. They grew as large as modern trees. Later, as the land dried and their seed-plant competitors evolved, the sphenopsids and ferns shrank to their present sizes and became restricted to small, moist areas.



The finely ribbed stems of this ancient species of vascular plants contain silicon.

Subphylum Sphenopsida (30 species)
The horsetails have true vascular tissue. Their leaves and branches are arranged in a characteristic, whorled pattern. The sporophytes have jointed stems, conspicuous ribs, and scalelike leaves. The sporangia are borne in a conelike structure at the top of the stem. The aerial stems arise from underground rhizomes that are perennial. The gametophytes are green, free-living organisms about the size of a pinhead.

Subphylum Pteropsida (211 000 species)
This group includes the ferns, conifers, and flowering plants. The vascular tissue is more complex in pteropsids than in sphenopsids, having a gap at the position of each leaf.

Class Filicineae (11 000 species)
The ferns are seedless vascular plants having a larger sporophyte alternating with a smaller, flat gametophyte. Spores are produced in groups of sporangia on the underside of the leaves. When mature, the spores are released and fall to the ground, where they grow into gametophytes. Male gametes formed in the gametophyes swim to the eggs, and the fertilized egg becomes a new sporophyte.

The leaves of the fern are divided into leaflets. The tips of the leaves bear numerous round sori containing sporangia.

Name ______________________ Date __________

Taxonomy 10
Kingdom Plantae

Phylum Tracheophyta, continued

Class Gymnospermae (700 species)
The gymnosperms include the familiar conifers, with their cones and needlelike leaves. Ancient members of this group were the first plants to produce seeds, arising 290 million years ago in the late Carboniferous times. Their leaves have many adaptations for drought resistance, a feature thought to be related to the period of worldwide aridity at about the time these plants first appeared.

Though seeds are the result of sexual reproduction, the gymnosperm gametophyte is much reduced. In most gymnosperms the sperm are nonmotile and are conveyed directly to the archegonium via the pollen tube. In cycads and ginkgos—more ancient members of this group—the sperm are flagellated. The large, visible plant is the sporophyte.

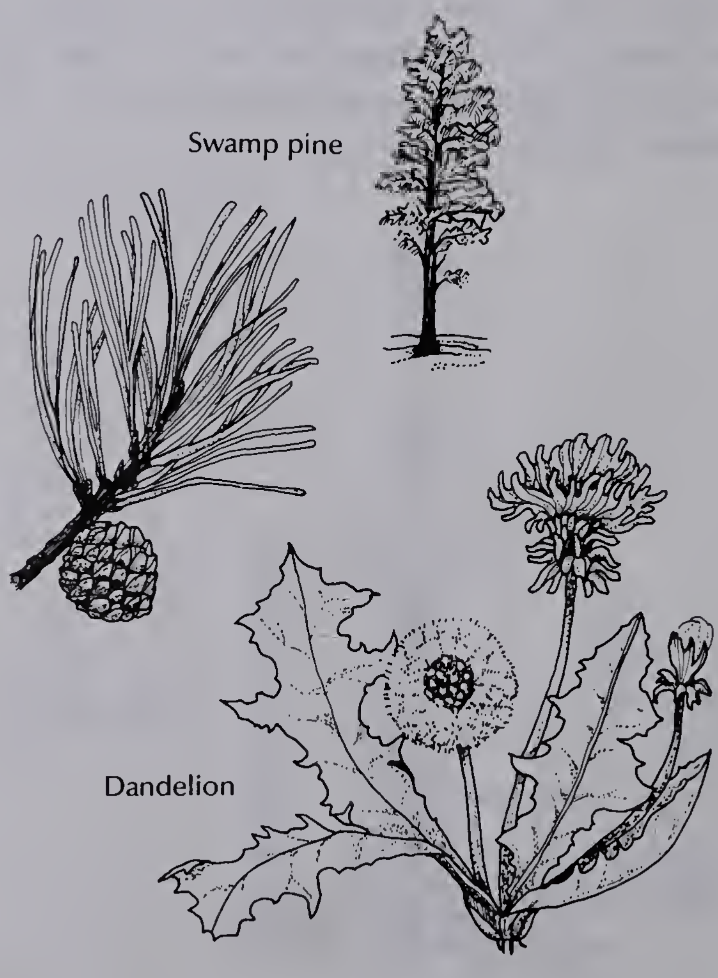
The main characteristic of this group is that the naked seeds of gymnosperms are not enclosed in fruits as are angiosperm seeds. This group includes the familiar pines, firs, spruces, junipers, and the tallest vascular plants, the redwoods.

Class Angiospermae (200 000 species)
These are the flowering plants, bearing seeds enclosed in fruits. Like the gymnosperms, the gametophyte is much reduced, sometimes to only a few cells or nuclei. A pollen grain is a male gametophyte. The angiosperms have double fertilization. As the egg is fertilized, another, simultaneous fertilization produces the endosperm, which is the stored food for the embryo.

Many angiosperms have co-evolved with insects as their pollinators; earlier species have adaptations for pollination by the wind. The angiosperms are extremely diverse in form and they inhabit every type of terrestrial region. For instance, the cacti are adapted for extremely arid conditions. Though the vast majority of flowering plants are free-living, some species live as saprophytes or parasites.

Subclass Monocotyledonae (34 000 species)
Usually the flower parts of monocots are in threes. Leaf veins are parallel, and each seed has just one cotyledon. In a cross-section of the stem, the vascular bundles appear scattered. Lilies and grasses are members of this group.

Subclass Dicotyledonae (166 000 species)
Not only do dicot seeds have two cotyledons, compared with the single cotyledon in a monocot seed, but the flowers and other plant parts appear more complex. The flower parts are in fours or fives, and the leaf veins form branched patterns. The vascular bundles in the stems are arranged in rings. Dicots include maples, begonias, roses, and oak trees, to name just a few.



The swamp pine has round cones and needles in bundles of three. The familiar seed head of the dandelion is adapted for wind dispersal.

Name ______________________________ Date ______________

Taxonomy 11
Kingdom Animalia

Like the plants, animals are eukaryotic and multicellular. This kingdom includes multicellular organisms that are not capable of photosynthesis. Like the fungi, they are consumers. Their principal mode of nutrition is by ingestion. Animals have no cell walls, as plants and fungi do. The main identifying feature of the majority of animal species is the ability to crawl, walk, swim, or fly—all forms of locomotion.

Most animals reproduce sexually, with diploid males and females producing haploid gametes that fuse to form a zygote. More than a million species of animals have been described; the vast majority of species fall within the phylum arthropoda, which includes the insects.

PHYLUM PORIFERA
(4200 species)

All sponges are aquatic; most are found in salt water, some are freshwater inhabitants. They have stiff skeletons and porous bodies that allow incoming water carrying food particles to circulate throughout; their mode of food-getting is by filter-feeding.

The skeletons are made of networks of needlelike structures called spicules. Their body forms are asymmetrical. Unlike most of the more complex animals, sponges cannot move, but are attached to rocks or other underwater substrates.

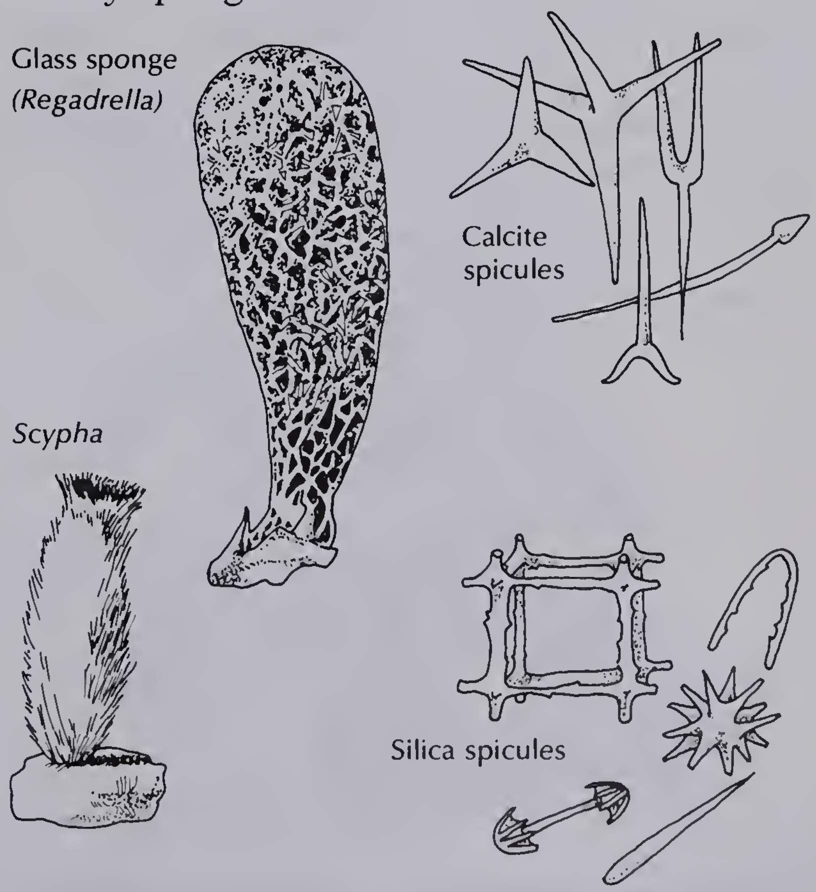
Sponges lack a coordinated nervous system, or even real nerve cells. Only two cell layers make up their bodies. Sponges may reproduce by sexual or asexual means. Some sponges are able to regenerate lost or injured parts. The sponges are classified on the basis of the material that goes into forming their spicules.

Class Calcarea (Calcispongiae)
In these sponges spicules of calcite (calcium carbonate) form the skeleton, which has a simple structure. This group includes the small chalky sponges.

Class Hexactinellida
The spicules of these deep-water sponges are made of silica and are arranged in an open framework, each spicule having six rays. Their skeletons may be very elaborate and delicate-looking. They are known as the glass sponges and have fanciful names, such as Venus' flower basket.

Class Demospongiae
The skeletal network of the Demospongiae is composed of spicules made of silica that are not six-rayed, or that are combined with spongin fibers. Some species, the horny sponges, have no spicules; their skeletons are made of horny, elastic spongin that contains a protein similar to that found in hair and feathers.

The sponges of this class may be brightly colored. They are found in both fresh water and salt water. The familiar bath sponge is a horny sponge.



Scypha is a simple sponge of the Class Calcarea. The spicules of the glass sponge are of silica.

Name ______________________________ Date ____________

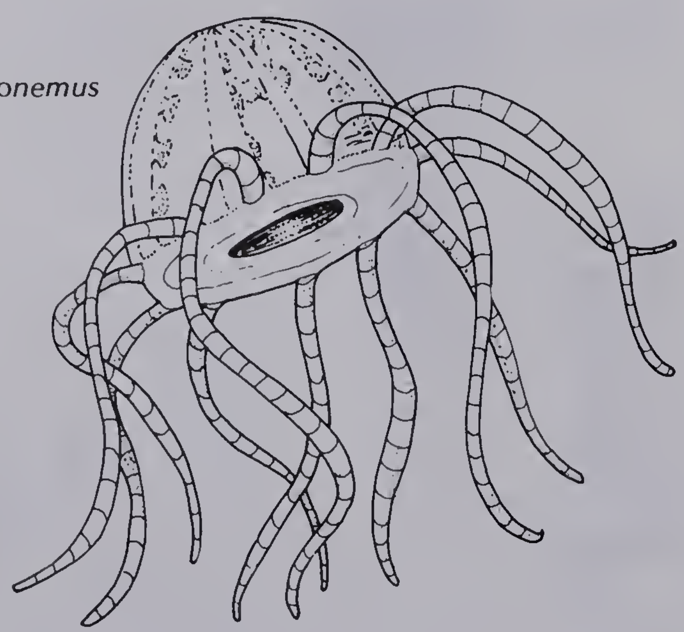
Taxonomy 12
Kingdom Animalia

PHYLUM COELENTERATA
(11 000 species)

Some of these jellylike, aquatic creatures swim; others remain attached to rocks. Their bodies are radially symmetrical. As predators on other ocean animals, coelentrates are equipped with tentacles bearing stinging cells that are used to paralyze their prey.

The body is like a pouch made of two cell layers; the main body cavity is the digestive gut, which has only one opening to the outside. Some are strictly polyps (plantlike in shape). Others are polyps during one part of the life cycle, and free-swimming medusas (bell-shaped structures) during another part.

The nerve cells of coelenterates are arranged in nets, without central coordination, so the entire body may react to a stimulus. These animals are able to regenerate parts. Asexual reproduction is usually by budding; most species also have sexual reproduction at certain times of the year.

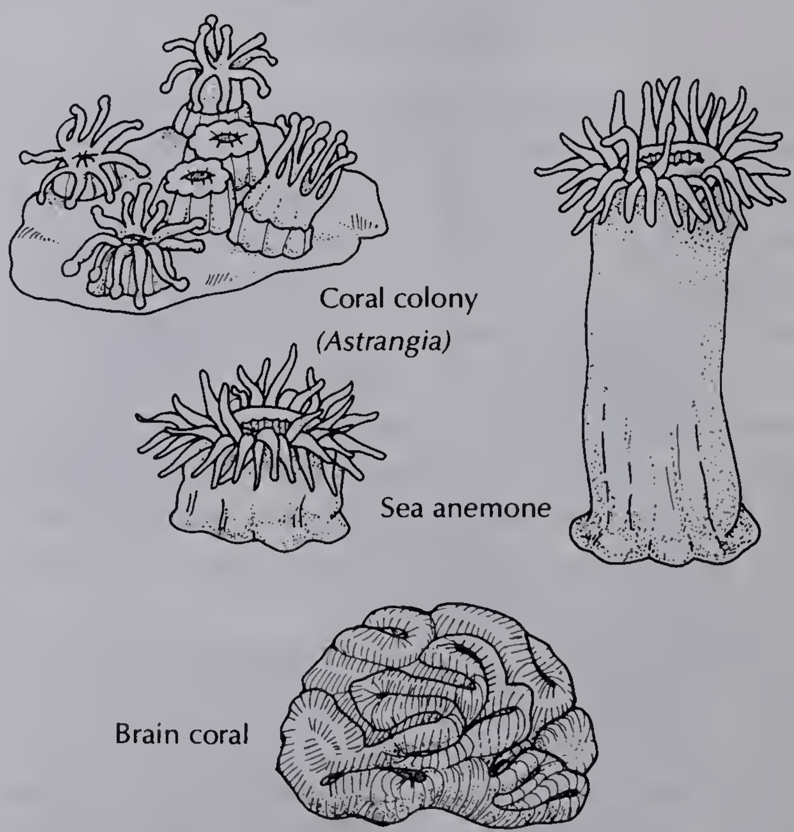


Gonionemus is considered to be close to the ancestral coelenterate. The medusa stage is well developed.

Class Hydrozoa (3700 species)
Most hydrozoans form polyp colonies that may give rise to medusas. The dominant form is a polyp. Some, such as the hydra, alternate between asexual and sexual generations. *Hydra*, *Obelia*, and Portuguese man-of-war are members of this class.

Class Scyphozoa (200 species)
The larger jellyfish are all medusas that live in salt water. The polyp stage is either lacking in some species or is very small. In some species the margin of the bell is fringed with tentacles. Equally spaced notches along the margin contain pigmented eyespots. These organisms have true muscle cells.

Class Anthozoa (6100 species)
No medusa form is present in these saltwater coelentrates; they are all polyps. They include the corals and sea anemones. They have a well developed nerve net and several sets of specialized muscles, including circular and longitudinal to aid in contraction of the polyps at low tide. Corals grow in large colonies and secrete shells of limestone that build up extensive reefs.



These coelenterates exist only as polyps. Most coral polyps remain contracted during the day and feed at night.

Name ______________________ Date ____________

Taxonomy 13
Kingdom Animalia

PHYLUM PLATYHELMINTHES
(15 000 species)

In these organisms, bilateral symmetry and real nervous systems can be seen. Their bodies are flattened and consist of three distinct cell layers, a characteristic of all advanced animals. Like more primitive animals, they have a gut with only one opening. There is no circulatory system, which limits the size of the free-living forms. Excretion is carried out by special structures called flame cells. These animals are hermaphroditic. Many are parasitic, but some are aquatic and free-living. Planaria, flukes, and tapeworms each represent different classes within this phylum.

Class Turbellaria
These are free-living, carnivorous flatworms, the most familiar of which are the planaria. Like many primitive animals, they have a remarkable capacity for regeneration.

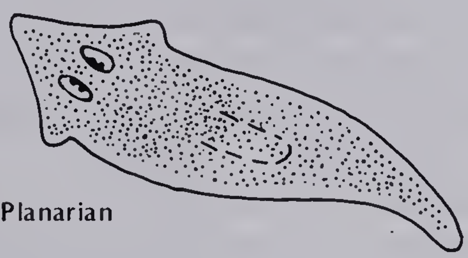
Planaria can swim by beating the cilia on their body surfaces, as smaller ciliated animals do; they also move by muscular contractions. Their conspicuous eyespots are light-sensitive areas, not true eyes. A two-lobed brain links two sets of nerve cords.

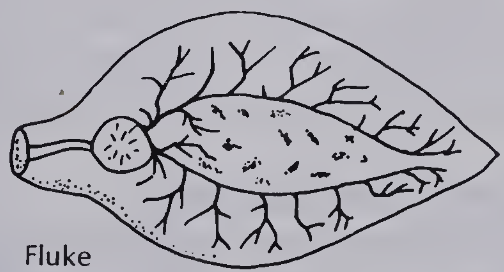
The planarian differs from the hydra in having a definite head region with eyes and other sense organs. Their reproductive system is highly complicated; they reproduce sexually and are hermaphroditic.

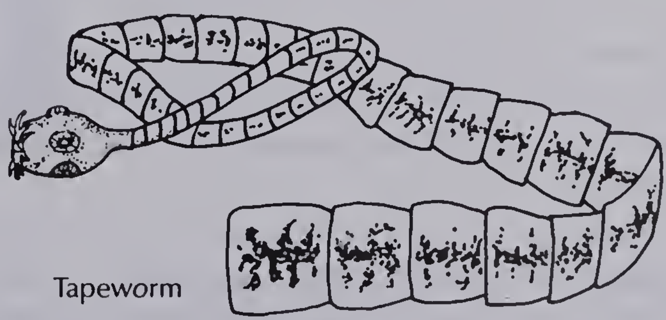
Class Trematoda
These parasitic flatworms have digestive tracts. They differ from turbellarians in lacking cilia and in having a thick cuticle covering their outer layer. A fluke attaches itself to a host using its powerful suckers and hooks that may be found at either end or on the ventral surface. Most of the interior of these animals is given to their reproductive system. Blood flukes cause their human hosts to become weakened and fatigued and may remain for years.

Class Cestoda
Like the flukes, the tapeworms are parasitic flatworms, but, unlike the flukes, they have no digestive tracts. A tapeworm attaches itself with suckers at the head end to a host's digestive tract and absorbs nutrients through its body surface. They are long, flat, ribbonlike worms, with each detachable segment being filled with eggs.

If eggs from a human tapeworm contaminate cattle feed, anyone eating rare beef from those cattle can be infected, as the bladders of the beef tapeworm become encysted in the muscle tissue.


Planarian


Fluke


Tapeworm

The flattened body form is apparent in each of these types of platyhelminth. The fluke and tapeworm are parasitic.

Name ______________________________ Date ____________

Taxonomy 14
Kingdom Animalia

PHYLUM ASCHELMINTHES
(12 500 species)

This group includes many diverse forms. They are alike in having bilateral symmetry, bodies covered with a cuticle, a muscular organ for feeding at the anterior end of the gut, and three cell layers. They may be parasitic or free-living.

Class Nematoda (10 000 species)
Some nematodes are parasitic on plants or animals, while others are free-living. Many are decomposers, breaking down dead matter in soil. Nematodes are so numerous that a spadeful of garden soil may contain millions of them. They have no circulatory system.

Several important parasites of humans are in this group: the trichina worm, that infects pork, and the filaria, which inhabits tropical and subtropical countries and causes elephantiasis in human hosts. Trichina, hookworms, vinegar eels, and other roundworms belong to this class.

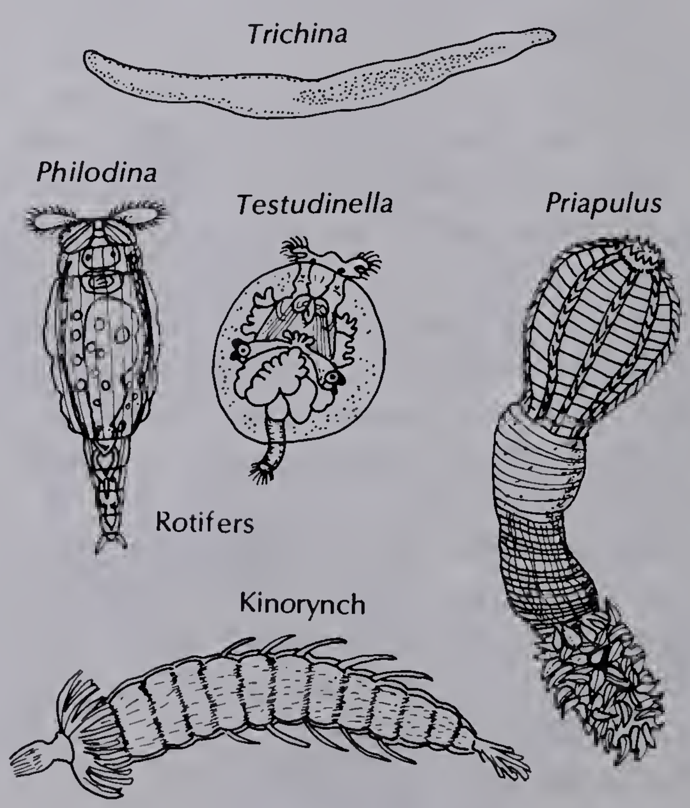
Class Rotifera (2000 species)
These microscopic organisms, about the size of protozoa, may be either wormlike or spherical. A distinguishing characteristic of the rotifers is a wheel-like ring of cilia at the anterior end that is the chief organ of locomotion. They have no circulatory system, but do have a complete digestive tract. Rotifers reproduce sexually and the sexes are separate.

Class Gastrotricha (140 species)
These very small or microscopic organisms live in fresh water. Cilia on their ventral surfaces aid them in locomotion. Their bodies are covered with a scalelike cuticle. Half of the known gastrotrichs live in the ocean; the rest live in fresh water. The saltwater species are hermaphroditic.

Class Kinorhyncha (100 species)
These microscopic, free-living animals live in salt water. They have beaklike snouts that can be protruded. Rings of thick cuticle cover their bodies. Their circulatory and reproductive systems are simple.

Class Priapulida (5 species)
Thick cuticle rings cover the bodies of these fleshy, free-living, wormlike animals; they have spines in their mouth region. *Priapulus* lies buried in sand with its mouth near the surface, ready to snatch slowly passing prey.

Class Nematomorpha (200 species)
These brown or black worms have long, slender bodies. Their larvae parasitize insects, but the adults are free-living. Their digestive tracts are simple. This group includes the horsehair worms.



The unsegmented roundworm *Trichina* is microscopic. The rotifer's ring of cilia is used in food-getting as well as in locomotion. The microscopic Kinorynch lives in mud. The wormlike *Priapulus* may reach a length of over 15 cm.

Name ______________________________ Date ____________

Taxonomy 15
Kingdom Animalia

PHYLUM BRYOZOA
(4000 species)

Like sea anemones and other attached forms, these small "moss animals" resemble plants. Bryozoans have bilateral symmetry, are aquatic, and feed with ciliated tentacles. Usually they grow in colonies. Each individual of a colony lives in a case of hard material, either calcareous or horny, that offers a protective retreat. Their digestive tracts are complete but curved into a U shape. Growth of a colony is by asexual budding. The larvae are retained in a brood pouch.

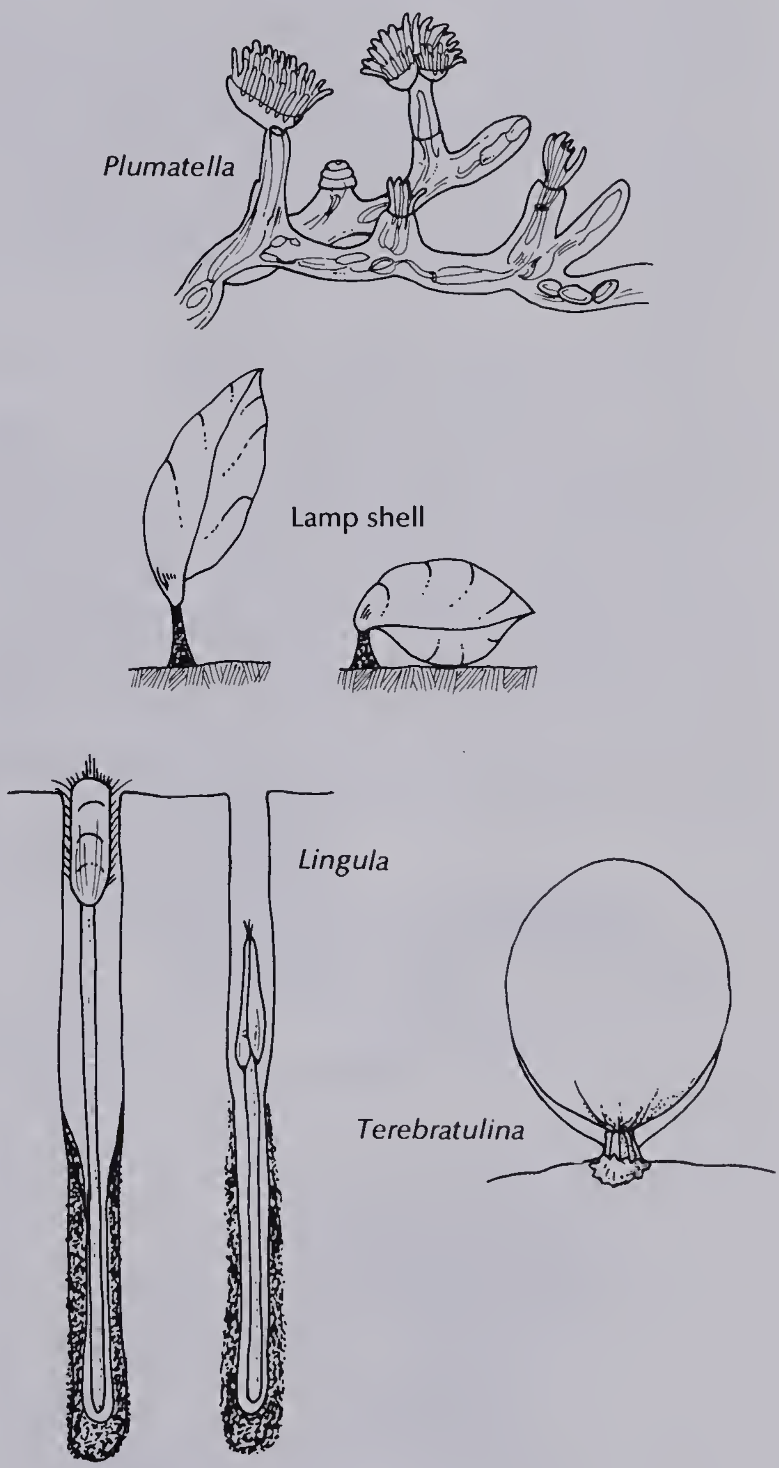
PHYLUM BRACHIOPODA
(260 species)

This is another group of attached saltwater animals; the posterior end of the body extends into a muscular stalk, the peduncle, by which the animal is attached, usually to a rock. Their paired shells look like clam shells except that the shells correspond to their dorsal and ventral surfaces, rather than right and left halves as in clams.

Brachiopods have "arms" known as lophophores that are coiled in spirals and have tentacles. They have a simple circulatory system which includes a contractile enlargement, a primitive kind of heart. Their symmetry is bilateral. The lamp shells are members of this group.

Class Inarticulata
These animals have shells of a chitinous material, and spicules made of calcium carbonate. There are no hinges joining the shells. The digestive tract is complete. *Lingula* is included in this class and is the oldest known genus of animals, estimated from fossils to have lived nearly 500 million years ago. Modern species of *Lingula* are nearly identical to their ancestral forms.

Class Articulata
In contrast to the previous group, these organisms have digestive tracts with only one opening. Their paired shells, made of calcium phosphate, are assymetrical and are linked by a hinge. *Terebratulina* is included in this class.



The freshwater bryozoan *Plumatella* feeds using its U-shaped row of ciliated tentacles. The lamp shell remains attached by its peduncle to a hard surface. *Lingula* attaches to the bottom of its sand burrow by a long stalk. *Terebratulina* lives underwater, attached to rocks by a stalk that emerges from a hole in one valve.

Name ______________________ Date __________

Taxonomy 16
Kingdom Animalia

PHYLUM ANNELIDA
(8800 species)

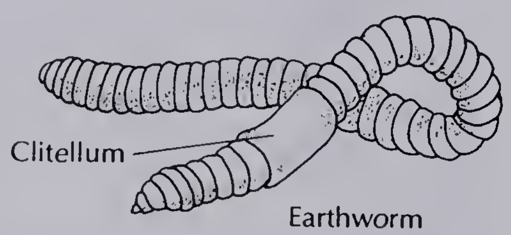
The segmented worms have complete digestive tracts, circulatory systems, and ventral nerve cords. Special excretory organs called nephridia are characteristic of this group. All are bilaterally symmetrical. Many are aquatic, some are parasitic, and others are free-living.

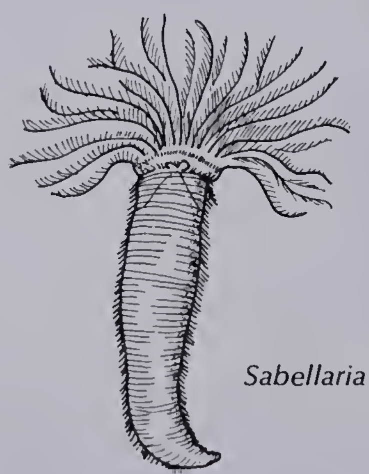
Class Polychaeta (4000 species)
These worms have heads possessing antennae, tentacles, and specialized mouthparts. They are named for the many bristles found on their appendages, or parapods. Most live in saltwater habitats. The polychaetes are very common to the seashore. Some, including the sandworms, live in mud tubes and burrows. Some have feathery gills that function in respiration and food-getting.

Class Oligochaeta (2500 species)
The head is not obvious in these terrestrial worms. Their bodies are sparsely covered with bristles. Segmentation is obvious, both internally and externally. The most commonly known species in this group is the earthworm.

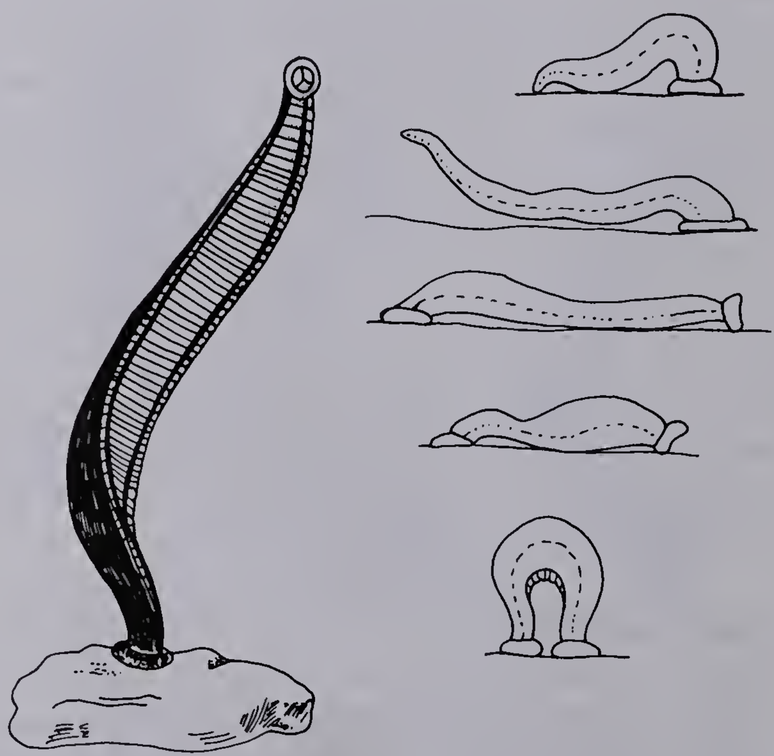
Class Archiannelida (35 species)
These saltwater worms are probably simplified annelids; they are not externally segmented and lack appendages and bristles. Many of them are ciliated. They are small and have a simple body plan.

Class Hirudinea (300 species)
The leeches are flat but have the characteristic segments of annelids. They lack bristles. In most cases the mouth is surrounded by a sucker; there is also a posterior sucker for attachment to the host. The digestive tract is pouched on both sides to allow for increased capacity to hold blood ingested from the host organism; this enables the leech to last months between blood meals. Free-living or parasitic, they are found in diverse habitats.





The clitellum is positioned differently in each species of earthworm. The polychaete has a head with sensory appendages and side feet having many bristles.



Leeches move in stages, using their front and rear suckers to pull themselves along.

Name ______________________ Date ____________

Taxonomy 17
Kingdom Animalia

PHYLUM MOLLUSCA
(110 000 species)

The mollusks are unsegmented animals having bilateral symmetry. They are found in terrestrial and aquatic habitats. Their soft bodies have a muscular foot, mantle, and head; some have hard shells for protection. Most have an organ called a radula for scraping food from hard surfaces. Mollusks have a three–chambered heart and complex digestive, circulatory, respiratory, and excretory systems.

Class Amphineura (700 species)
The bodies of these simple animals, the chitons, are covered by a mantle with overlapping shell plates imbedded in it. They cling by means of a broad muscular foot to rocks in intertidal coastal zones. As they move about slowly over the rocks, they rasp off fragments of algae. Chitons are able to roll up when disturbed, thereby protecting their soft parts.

Class Gastropoda (80 000 species)
Most gastropods have an asymmetrical spiral shell; some, such as slugs, have no shells. The head bears one or two pairs of tentacles. Most species in this group have well-developed sense organs. This class includes the snails, whelks, slugs, limpets, and sea hares.

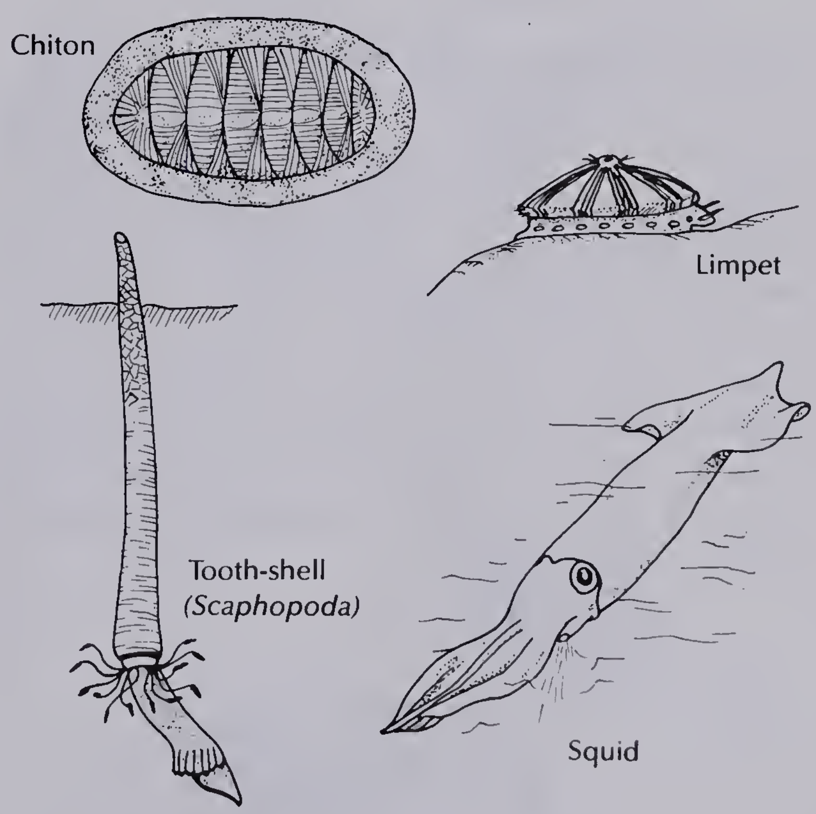
Class Scaphopoda (350 species)
The tooth-shells live in salt water, housed in conical shells. They reach out with their tentacles for food.

Class Pelecypoda (15 000 species)
These animals have soft bodies protected by two hinged shells that correspond to their left and right body halves. Most do not move. They possess a foot that is hatchet-shaped, and have no obvious head region. Clams, mussels, oysters, and scallops belong to this class of mollusks.

Class Cephalopoda (400 species)
These are the largest and most highly organized of the mollusks. The combined head-foot has eight or ten arms bearing many tentacles. They lead an active, predatory life and have well-developed nervous systems and simple eyes able to perceive images.

Cephalopods may have internal or external shells, or none at all. Their circulatory systems are improved over that of the clam, allowing for rapid distribution of oxygen through the tissues. Blood is pumped through the gill hearts and a single systemic heart.

The cephalopods swim by ejecting jets of water that propel them in one direction. When attacked they emit an inky material that clouds the water and affords them escape. Members of this group include the squids, octopuses, and nautiluses.



The shell of the chiton consists of eight plates. The limpet uses its muscular foot to creep slowly over rocks. The tooth-shell lives in sand. The squid is jet-propelled, directing its siphon forwards or backwards.

Name ______________________________ Date ____________

Taxonomy 18
Kingdom Animalia

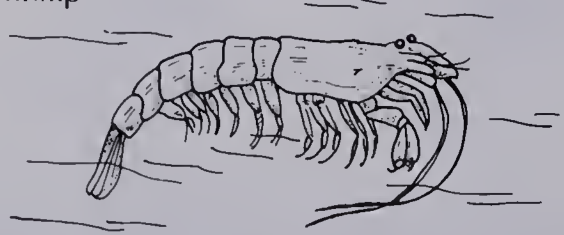
Phylum Arthropoda
(774 000 species)

The structures characteristic of this group are jointed appendages, which may be elaborately modified for various purposes. In addition, arthropods have a complete digestive tract, an exoskeleton, a dorsal "brain", and a ventral nerve cord and ganglia. Since this phylum includes the insects, it numbers more species than any other animal phylum.

Class Onychophora (70 species)
These animals have many short, unjointed legs. Some of their characterisics are annelidlike, and others are arthropodlike. They live in tropical terrestrial habitats. The velvet worms are members of this group.

Class Crustacea (30 000 species)
The crustaceans are a diverse group living in oceans, in fresh water, and on land. Most are very small first-order consumers. Crustaceans breathe by means of gills. They have two pairs of antennae, one pair of mandibles, and usually two pairs of maxillae. They have several pairs of appendages on the thorax and sometimes also on the abdomen. This group includes the brine shrimps, water fleas (*Daphnia*), barnacles, lobsters, crabs, and wood lice.

Shrimp



The shrimp is a crustacean; this one inhabits salt water.

Class Arachnida (35 000 species)
Most of these are terrestrial, air-breathing animals. They have two main body sections, the cephalothorax bearing six pairs of appendages, and an abdomen. Of the appendages, four or five pairs are walking legs. The first pair of appendages is modified for grasping. They have fangs or pincers, but no jaws or antennae. Spiders, scorpions, ticks, and mites are representatives of this class.

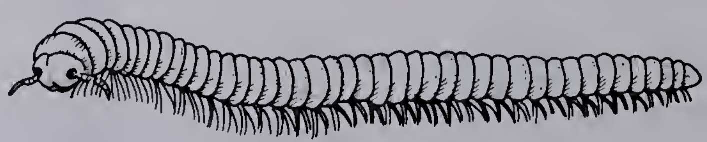
Class Chilopoda (2000 species)
Centipedes have a flattened body divided into 15 to 173 segments, each having one pair of appendages. They have one pair of antennae and one pair of poison glands. These animals prey mainly on insects.

Class Diplopoda (7000 species)
Diplopods have bodies that are elongated, and they have one pair of short antennae. There are 20 to 180 segments making up a millipede's abdomen, each having two pairs of appendages. These animals have no poison glands, for they are not predators but decomposers.

Black widow

Scorpion

Millipede



The black widow spider inflicts an extremely poisonous bite. The scorpion stings its insect prey with the poisoned tip of its tail. The millipede lives among decaying leaves and under logs.

Name ________________________________ Date ______________

Taxonomy 19
Kingdom Animalia

Phylum Arthropoda, continued

Class Insecta (700 000 species)
Most insects are terrestrial, though many have an aquatic larval stage. Among the insects are the only flying invertebrates. Most insects have tracheae, one pair of antennae, three pairs of legs, and three distinct body divisions—head, thorax, and abdomen. The insects are a diverse and numerous group, having radiated into nearly every habitat except the open ocean.

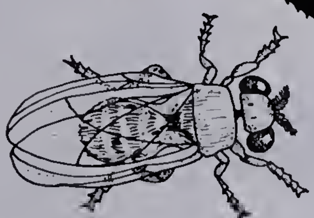
Order Coleoptera (280 000 species)
These insects, which include the beetles, have two pairs of wings, a hard front pair and a membranous hind pair. Their mouthparts are adapted for chewing.

Order Diptera (85 000 species)
The dipterans have only one pair of wings. They possess sucking and piercing mouthparts. Flies and mosquitoes are representative of this group.

Order Hemiptera (40 000 species)
The mouthparts of these true bugs are adapted for sucking. Their wings become thinner from base to tip. The giant water bug is a member of this order.

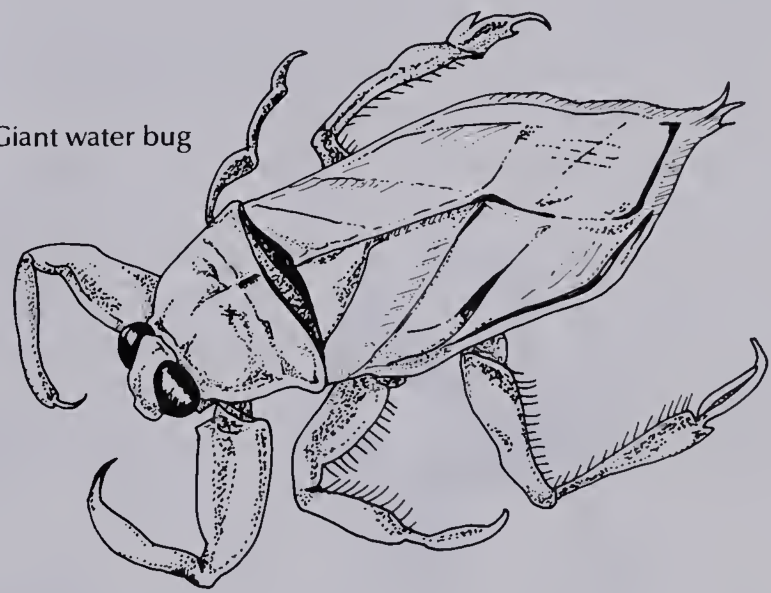
Order Homoptera (32 000 species)
These insects have wings that are lifted above their body; or, they may be wingless. They have sucking mouthparts. Among this group are the leafhoppers, plant lice, and cicadas.

Caterpillar hunter



Fruit fly

Giant water bug



Annual cicada

The caterpillar hunter is a large beetle that feeds on insects. The larvae feed on gypsy moth caterpillars and tent caterpillars. Fruit flies have a life cycle of less than two weeks.

The giant water bug, found in freshwater ponds and streams, attacks other insects, snails, and small fish. It measures about 5 cm. Male cicadas produce a humming sound by means of plate-like organs on their thorax.

Name ______________________ Date ____________

Taxonomy 20
Kingdom Animalia

Class Insecta, continued

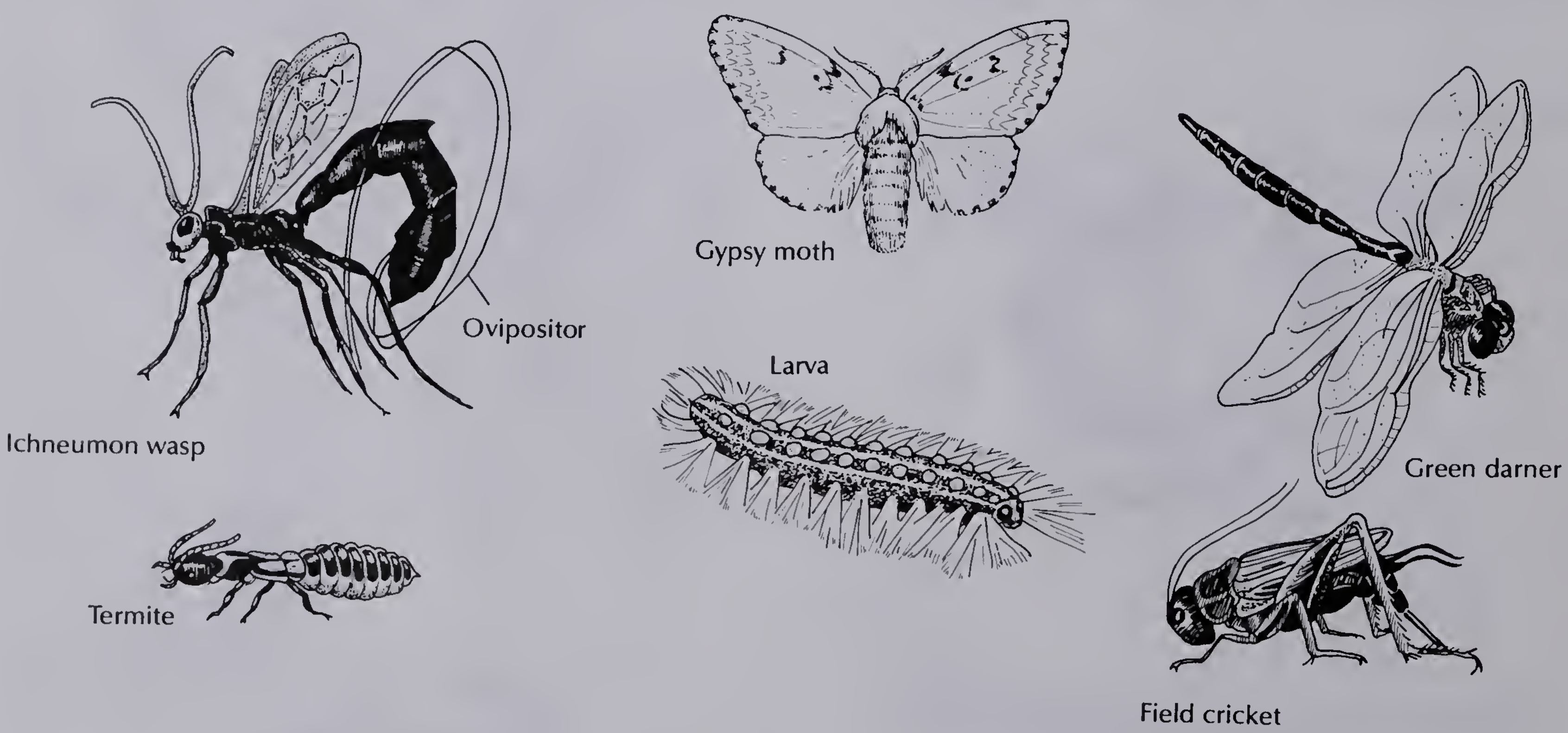
Order Hymenoptera (105 000 species)
Some of the hymenopterans, a group which includes bees, ants, and wasps, are wingless, and others have hind wings that are shorter than their front wings. All have chewing or sucking mouthparts; some have stingers. These insects exhibit a high degree of social structure.

Order Isoptera (2000 species)
These animals have two pairs of wings, and chewing mouthparts. This order includes the termites, which can feed on wood because of their mutualistic relationship with cellulose-digesting bacteria living in their intestines.

Order Lepidoptera (112 000 species)
Sucking mouthparts and two pairs of scaly wings characterize the order of insects that includes butterflies and moths. The antennae of butterflies end in small knobs; those of moths are feathery.

Order Odonata (5000 species)
Insects in this group have two pairs of long wings and mouthparts that are adapted for chewing. Dragonflies and damselflies are representative members of this order.

Order Orthoptera (23 000 species)
These insects have chewing mouthparts, narrow forewings that are parchmentlike and veined, and membranous hindwings that fold fanlike beneath the forewings. Some species are wingless. They are mostly plant feeders. This group includes the grasshoppers (locusts), and crickets. Locusts can be extremely destructive to crops as they swarm in large numbers, eating every bit of leafy material in their path.



Ichneumon wasps' larvae parasitize caterpillars and larvae of many insects. The female's ovipositor can pierce deeply into wood. The life cycle of the termite involves six stages over a two-year period. When gypsy moth larvae emerge in the spring they devour leaves of most shade and forest trees. The green darner lays its eggs on water plants or in the water. The nocturnal cricket produces a shrill sound by rubbing its forewings together; it is an herbivore, causing extensive crop damage.

Name ______________________________ Date ______________

Taxonomy 21
Kingdom Animalia

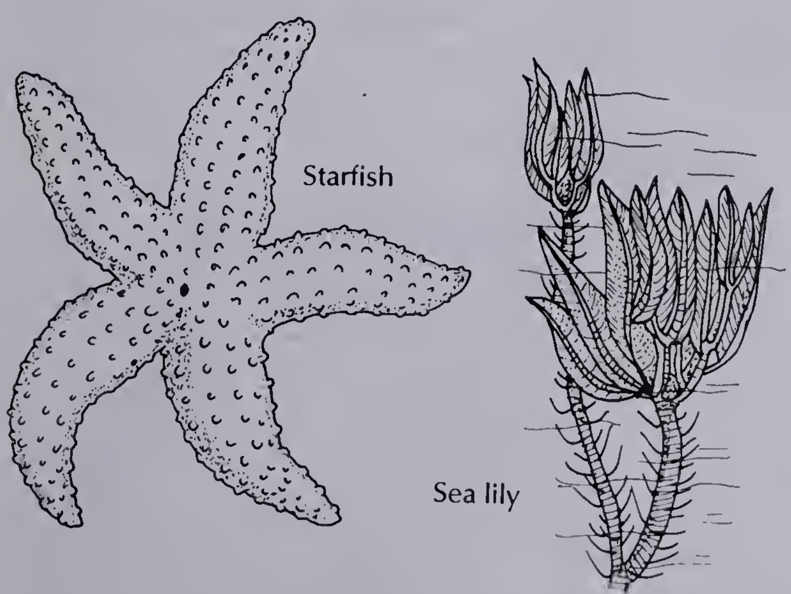
PHYLUM ECHINODERMATA
(6000 species)

Adult echinoderms have radial symmetry; the larvae are bilaterally symmetrical. It is generally held that chordates may have evolved from echinoderm larvae.

Echinoderms' bodies are spiny; members of this group include starfishes, sea urchins, and sand dollars. A unique water vascular system enables them to use suction for moving and for opening clam shells for food. They have three cell layers and are found in every saltwater habitat.

Class Asteroidea (1600 species)
The mouth in these animals is located on the undersurface. Their hard skeletons have many calcareous spines, or projections. Their mode of locomotion is by means of a hydraulic pressure system, known as the water vascular system.

The starfish, a member of this class, may have from 5 to 50 arms, in multiples of five. Each arm has many pairs of tube feet located on the ventral surface. The tube feet are connected to the water vascular system.



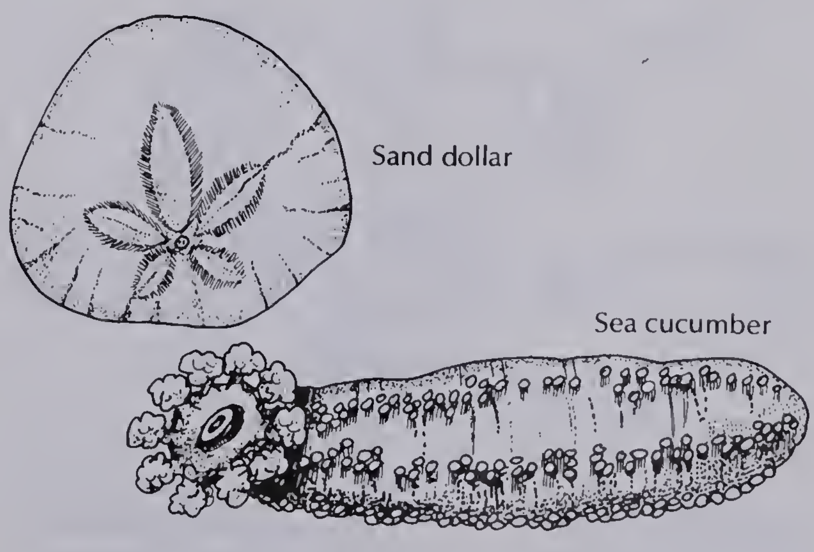
The starfish is common to rocky shores. The sea lily, a crinoid, is flowerlike in appearance.

Class Crinoidea (630 species)
Most of the echinoderms in this group are extinct and are seen only as fossils. They live attached to rocks or other substrates by jointed stalks. Their arms are divided into thin branches. The crinoids and sea lilies belong to this class.

Class Ophiuroidea (2000 species)
These animals closely resemble starfish; they have very long, slender arms and can move about rapidly. They include the serpent stars and brittle stars.

Class Echinoidea (860 species)
This class of echinoderms has no arms. It includes the sea urchins and sand dollars. Though these echinoderms seem very unlike starfishes, they have the same basic structure; they are radially symmetrical and have five rows of tube feet that correspond to the five arms of the common starfish. The external, rigid covering of these animals has many movable spines.

Class Holothuroidea (900 species)
The bodies of these animals are long and shaped like cucumbers; they are called sea cucumbers. The spines usually found in echinoderms are present in these animals as tiny ossicles embedded in the skin. They creep along the ocean floor by muscular movements of their body wall.



The sand dollar swallows sand and digests organic material contained in it. The sea cucumber is a fleshy echinoderm; slime-covered tentacles surrounding its mouth trap small animals.

Name ______________________________ Date ____________

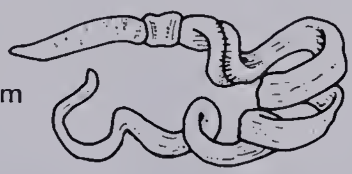
Taxonomy 22
Kingdom Animalia

PHYLUM CHORDATA
(45 000 species)

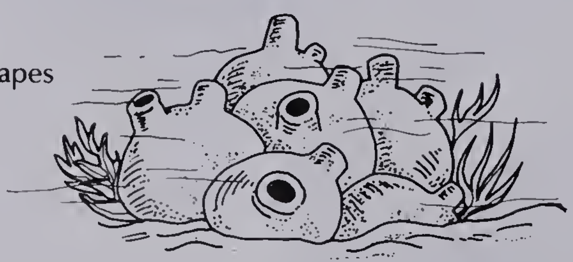
The chordates have a notochord, a dorsal, hollow nerve cord and gill slits at some time in their development. In addition, chordates are characterized by bilateral symmetry, three cell layers, and paired appendages. They reproduce sexually. There are 45 000 species of chordates, over 43 000 of which are vertebrates.

Subphylum Hemichordata (100 species)
These small, wormlike animals live in saltwater. Because of their controversial notochord, they are not always classified as chordates. They have gill slits and a solid nerve cord. Tongue worms and acorn worms are members of this group.

Tongue worm



Sea grapes



Lancelet

The tongue worm uses its proboscis to burrow into sand or mud along seashores. Sea grapes grow on rocks and piling. The fishlike lancelet burrows into shifting sand in shallow waters; it can also swim by moving its body from side to side.

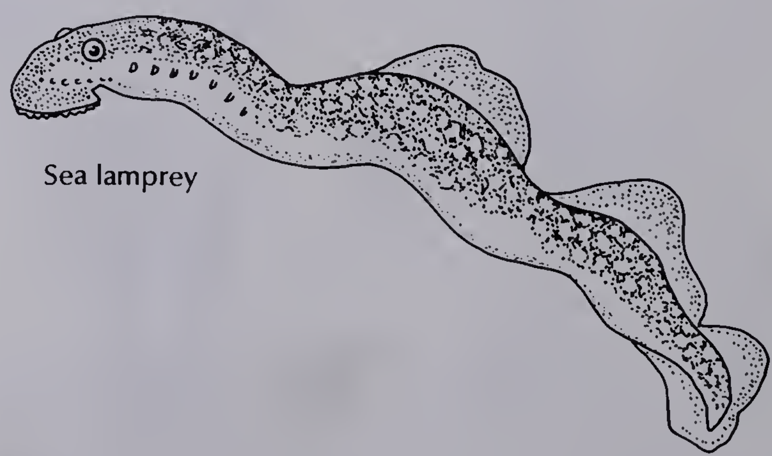
Subphylum Urochordata (1600 species)
These are saclike, colonial animals that usually attach to rocks in saltwater as adults. They feed by creating water currents with their cilia, filtering out organisms for food. Though the larvae are clearly chordates, the adults have no notochord. The group includes the sea squirts, sea grapes, and tunicates.

Subphylum Cephalochordata (13 species)
Found in saltwater habitats, these fishlike animals are perfect examples of the basic chordate. They have neither cartilage nor bone, retaining the notochord throughout life. They have gill slits and are filter feeders. Lancelets (*Amphioxus*) belong to this group.

Subphylum Vertebrata (43 000 species)
In vertebrates, the notochord is replaced in adults by cartilage or bone, forming a segmented vertebral column, and the brain is enclosed in a skull. Most can move around, but a few are attached to rocks. Vertebrates are found in aquatic and terrestrial habitats. All but the birds and mammals are cold-blooded.

Class Agnatha (10 species)
These are eellike, jawless fish. They have no limbs, bones, scales, or fins. The notochord persists in adults, but there is also a cartilaginous skeleton. These fish, which include the lampreys and hagfish, are parasitic; they feed by sucking fluids from their hosts.

Sea lamprey



The sea lamprey has seven pairs of gill slits. Parasitic species attach to fishes.

Name ______________________ Date __________

Taxonomy 23
Kingdom Animalia

Subphylum Vertebrata, continued

Class Chondrichthyes (600 species)
The cartilaginous fishes have skeletons made of cartilage, not bone. Their bodies are covered with scales which may be modified to form teeth that grow continuously. They have paired fins and large, uncovered gill openings. The three-chambered heart has only one ventricle.

In these fishes, fertilization is internal. Eggs may develop externally or internally; offspring are born live. Most of these fishes live in salt water; they include the sharks, rays, and skates.

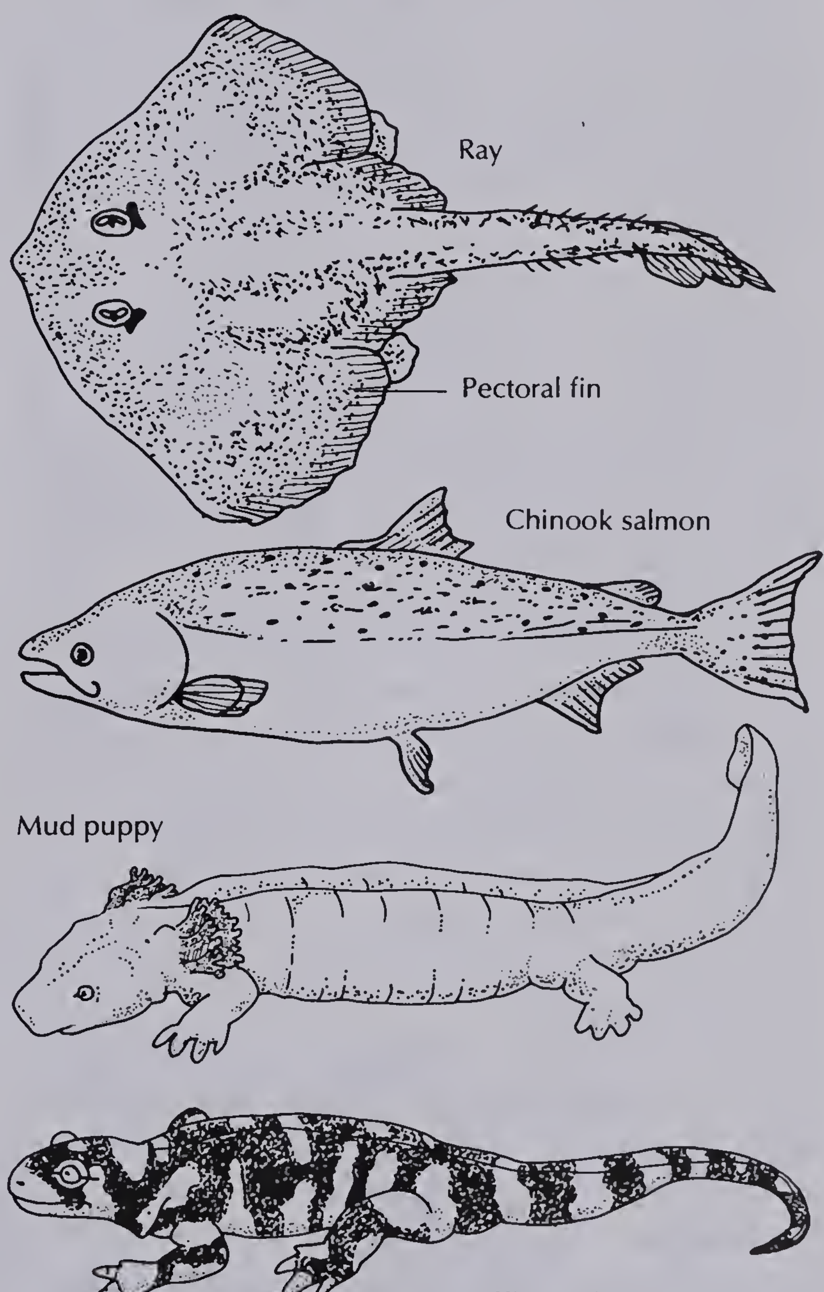
Class Osteichthyes (20 000 species)
The bony fishes make up the largest vertebrate class. They are widespread in saltwater and freshwater habitats. Most have an air bladder; a few have lungs. The gills have hard covers, and the body is covered with scales.

Most bony fishes are ray-finned, having rays or spines to support each paired fin. Most of these fishes have externally fertilized eggs; in a few cases the ova are internally fertilized and the young are born fully developed. Sturgeon, trout, perch, and lungfishes are members of this class.

Class Amphibia (2000 species)
Early amphibians were the first vertebrates to live on land. Aquatic as larvae, the animals may be either aquatic or terrestrial as adults. Their skins are usually moist and smooth. Some amphibians, such as salamanders, appear lizardlike. In fact, the amphibians are ancestors of the reptiles.

Most adult amphibians have legs. Their skeletons are largely bony. In most cases the larvae breathe through gills, with lungs developing during metamorphosis to the adult form. Nostrils connect the mouth cavity to the lungs. They have a three-chambered heart with only one ventricle. Senses of sight and hearing can function in water as well as in air; the eyes often have movable eyelids.

Fertilization is external, and the eggs must develop in water. Salamanders have a long tail and a distinct head and neck region while frogs and toads have the head and trunk of the body joined, are tailless, and have short forelimbs and long hindlimbs to aid in jumping.



The ray, a cartilaginous fish, swims by flapping its pectoral fins. Salmon are streamlined bony fish that swim fast and cover long distances from fresh water to oceans and back again. The mud puppy retains its gills as an adult. Its tail is finned, an adaptation to aquatic life. Subspecies of tiger salamanders differ in their patterns of stripes.

Name ______________________________ Date ____________

Taxonomy 24
Kingdom Animalia

Subphylum Vertebrata, continued

Class Reptilia (5000 species)
Reptiles are very diverse in their forms and habitats. They may be either terrestrial or aquatic. They are all coldblooded. They are the first group of vertebrates adapted for life on dry land. Their dry skin, usually covered with scales, resists loss of moisture from the body.

Many species have two pairs of legs; snakes have none. The limbs of turtles are paddlelike, an adaptation to an aquatic environment. The limbs have toes tipped with horny claws. Lungs are used throughout their life. They have a four-chambered heart with two ventricles. The skeleton is composed entirely of bone.

Fertilization is internal, producing an embryo that is surrounded by membranes and enclosed in a leathery or limy egg shell. Most species deposit their eggs to develop outside the mother's body. The embryo develops on land and is not restricted to a watery environment. Internal development of the embryo is found in vipers, rattlesnakes, and water snakes.

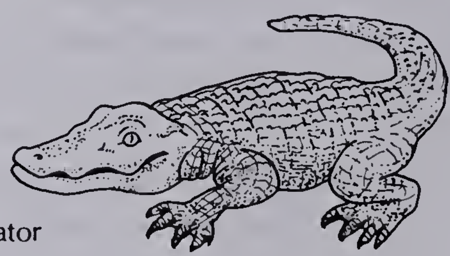
A characteristic of many lizards is their ability to change color; this is under nervous and hormonal control. Snakes that are poisonous have specialized teeth called fangs that conduct venom in a bite that paralyzes and kills the prey. Lizards, snakes, turtles, alligators, geckos, and gila monsters are all examples of reptiles.

Class Aves (8600 species)
Birds are found in terrestrial and aquatic habitats. As a group, they are more like one another than are members of other vertebrate classes.

Birds are warmblooded, and their skin is covered with feathers that provide insulation and help regulate their body temperature. The forelimbs are modified as wings, enabling flight. Their bills serve as both mouth and hands and may also be used in defense. The structure of a bird's bill is important in determining the bird's ecological role. For example, the form of the bill is usually related to the bird's food habits.

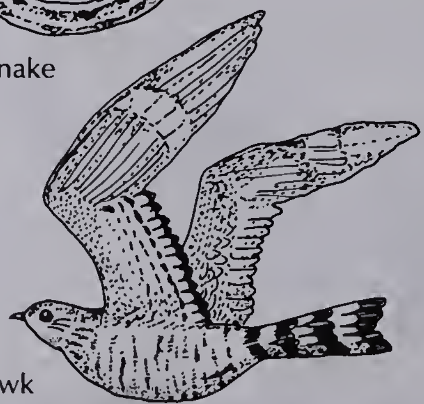
Birds have lungs throughout their lives; the heart is four-chambered. Fertilization is internal, and the embryo develops externally, enclosed in a limy shell and surrounded by protective membranes.

Birds are toothless and are the only animals with feathers. Some biologists theorize that birds evolved from warmblooded dinosaurs. Many birds have a migrating habit; this may be across latitudes north and south, or altitudinal. Pigeons, chickens, gulls, sparrows, parrots, cranes, and woodpeckers are only a few examples of the diverse species of birds.



Alligator

Common garter snake



Common nighthawk

The alligator is larger than the crocodile and has a wide, blunt snout. Garter snakes feed on frogs, toads, and earthworms. The common nighthawk forages by night, capturing insects.

Name ______________________________ Date ____________

Taxonomy 25
Kingdom Animalia

Subphylum Vertebrata, continued

Class Mammalia (4500 species)
This class of vertebrates is thought to have evolved from a group of reptiles different from those that were ancestral to birds. Mammals live in every kind of habitat, from the polar regions to the tropics, from the sea to the densest forests and driest deserts. They are warmblooded creatures covered with hair or fur that serves as insulation.

Mammals have highly efficient respiratory and circulatory systems as do the birds. They have four limbs, a lower jaw made of one pair of bones, and three bones in each middle ear. Mammals have lungs, and a muscular diaphragm that aids in respiration. The heart is four-chambered.

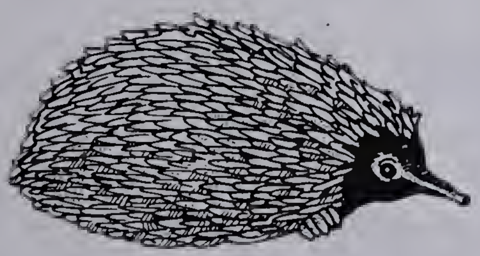
Fertilization in mammals is internal. In most mammals, the embryo develops within the mother's body, surrounded by amniotic fluid; the embryo is attached to the mother by an umbilical cord that connects to the placenta, an organ that functions in gas exchange and waste removal.

The young are nourished with milk produced by the mother's mammary glands. Parental care is most highly developed in this class of animals, in particular the human species.

Order Monotremata (5 species)
The duckbilled platypus and the spiny anteater of Australia are the only mammals that lay eggs. These mammals have teeth only when young; teeth are replaced by a horny beak in adults. Their mammary glands are functional but have no nipples.

The platypus is aquatic and feeds on freshwater invertebrates. The spiny anteater, or echidna, is able to extend its tongue through its cylindrical beak to catch ants and termites. A single egg laid by the female is incubated in a pouch on the abdomen.

Order Marsupalia (250 species)
The marsupials are the only mammals whose offspring are born partly developed after only a few days in the uterus following fertilization. Development is completed in a pouch, the marsupium, on the mother's abdomen. Each premature fetus is attached by its mouth to one of its mother's nipples, where it remains until fully developed. Following this stage the young may retreat to their mother's pouch for protection. Kangaroos, opossums, and phalangers are all marsupials.



Spiny anteater *(Echidna)*

Koala

Kangaroo

The spiny anteater is toothless; it uses its sticky tongue to catch termites and ants. The koala is an Australian marsupial that lives in and eats the leaves of eucalyptus trees. Kangaroos are active mostly at night; a "joey" leaves its mother's pouch permanently at about 10 months of age.

Name ______________________________ Date ____________

Taxonomy 26
Kingdom Animalia

Subphylum Vertebrata, continued

Order Insectivora (400 species)
These omnivorous mammals, the moles, shrews, and hedgehogs, have many small teeth. They are small, and most are nocturnal. They feed chiefly on insects and worms. The moles are burrowing animals with small covered eyes. Shrews forage on the surface of the ground and in animal burrows. Hedgehogs have spines on their back and sides; they roll into a ball as a defense tactic.

Order Edentata (30 species)
These are small-brained creatures having only back teeth or no teeth at all. Their toes are clawed. Many feed on ants and termites. This order includes the sloths, armadillos, and anteaters. Some sloths are arboreal and hang upside down on trees, clinging with their curved claws. Armadillos are covered with a horny shell attached to bony plates and can curl up when disturbed.

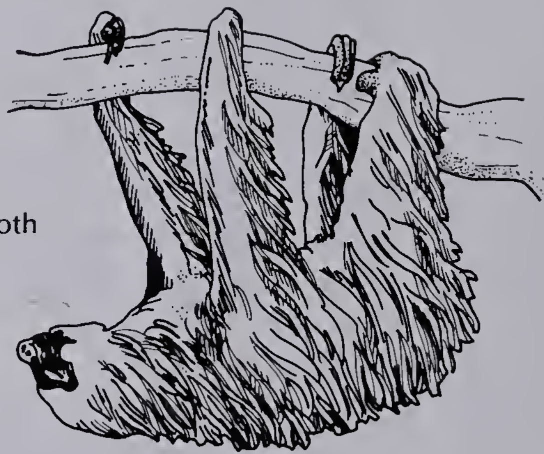
Order Pholidota (8 species)
These mammals, which eat ants and termites using their long slender tongue, have no teeth. Their bodies are covered with scales. The pangolin, or scaly anteater, is included in this group.

Order Tubulidentata (1 species)
Only a few teeth are found in the adult aardvark. Their toes end in structures that are somewhat hooflike, somewhat clawlike. They have a piglike body, are nocturnal, and dig in ground nests for ants and termites, which they catch with their long tongue.

Order Chiroptera (900 species)
The bats are small mammals that have rather large brains for their size. They can fly, using webs of skin between their appendages and fingers as wings. They are mostly active at dusk or at night.

Short-tailed shrew

Two-toed sloth



Aardvark

Common brown bat

The shrew has minute eyes; it uses its powerful forelegs to build its burrow. Sloths live in tropical rain forests, feeding on leaves as they creep along branches. The piglike aardvark feeds on termites and ants using its long sticky tongue. Bats glide through the air aided by a leathery membrane stretched between their limbs.

Name ______________________ Date ____________

Taxonomy 27
Kingdom Animalia

Subphylum Vertebrata, continued

Order Dermoptera (2 species)
The flying lemurs glide through the air, using winglike webs of skin between their appendages and tail. They resemble flying squirrels. The colugo is a member of this group. They are nocturnal and feed on leaves and fruit.

Order Carnivora (280 species)
Most, but not all of these mammals are carnivorous; they are found in terrestrial or aquatic habitats. They have adaptations for a carnivorous diet, including large, pointed canine teeth, called fangs, some sharp molars, and toes with claws. Tigers, giant pandas, wolves, dogs, raccoons, weasels, bears, walruses, seals, and skunks are included among the carnivores.

Order Rodentia (1700 species)
Rodents are distributed worldwide; most are terrestrial, some are semiaquatic. This group includes the majority of living mammals. Most species are fairly small, measuring less than a third of a metre. They gnaw their food, using chisellike incisors that grow continuously. They feed on leaves, stems, seeds, and roots mainly; some are insectivorous.

The smaller species of rodents tend to reproduce in large numbers. Rodents are a staple food for many carnivorous birds, reptiles, and mammals. This group includes porcupines, rats, prairie dogs, voles, squirrels, mice, beavers, and gophers.

Order Lagomorpha (60 species)
These herbivores have short stubby tails. There are four continuously growing chisellike incisors in a lagomorph's upper jaw. They feed on leaves, stems and bark. Rabbits, pikas, and hares belong to this group. The pikas live at high altitudes and spend the winter beneath rocks eating the hay they have collected and stored earlier in the year.

Order Hyracoidea (1 species)
The hyraxes are herbivorous mammals; they have no canines. They have nails in place of hooves; their skeletons are somewhat like an elephant's. They resemble a guinea pig. They are diurnal and prefer to live in rocky areas.

Hog-nosed skunk

North American porcupine

Rock hyrax

The hog-nosed skunk, the largest skunk in North America, roots for insects with its snout. Porcupines have hair that is modified into sharp spines, or quills. The North American porcupine feeds on inner bark of trees. The hyraxes, also called conies, are rabbit-sized mammals that climb rocky cliffs and sometimes trees.

Name ______________________________ Date ____________

Taxonomy 28
Kingdom Animalia

Subphylum Vertebrata, continued

Order Primates (200 species)
The eyes of primates face forward; they are capable of binocular vision. They have well-developed incisors, canines, and molars. Most have nails on their toes. An important primate characteristic is their opposable thumbs, enabling them to grasp objects and perform tasks requiring fine manipulation, sometimes using tools.

This order includes the lemurs, monkeys, apes, and humans. Most primate species are arboreal and live in tropical and subtropical regions.

Suborder Prosimii These are the earliest primates to have evolved. Their tails are long and are not prehensile (able to be used to grasp or cling to branches). They are chiefly nocturnal and their food is mostly seeds and fruit.

Lemurs, tarsiers, tree shrews, and lorises are all prosimians. The lorises and tarsiers have large eyes; the tarsier is able to jump like a frog and has a diet of insects and lizards.

Suborder Anthropoidea This group includes monkeys, apes, and humans. The main characteristics are an enlarged cranium housing cerebral hemispheres that extend over the cerebellum. Their facial muscles permit emotional expression; the ears are reduced in size and lie close to the head. Incisors are broad. Posture is more or less upright. The fingers and toes have flat nails. These primates are often social. They may live in trees or on land and are diurnal.

Superfamily Ceboidea These are the New World monkeys, found in Central and South America. Some species have a prehensile tail. Their nostrils are widely separated. Marmosets and spider monkeys belong to this group.

Superfamily Cercopithecoidea The Old World monkeys include baboons, Rhesus monkeys, mandrills and other African monkeys. Their habitats range from tropical rain forest to open grasslands and even semi-desert. Their tails are never prehensile; their nostrils are spaced close together. They have exposed patches of skin on their buttocks. The Rhesus monkey has been very important in scientific research.

The spider monkey uses its tail to cling to branches and pick up objects.

The baboon, an Old World monkey, has highly developed eye-hand coordination.

Name ______________________ Date ____________

Taxonomy 29
Kingdom Animalia

Subphylum Vertebrata

Superfamily Hominoidea The hominoids have a human appearance. They have no tail. This group includes the anthropoid (manlike) apes and humans.

Family Pongidae These are the apes: chimpanzees, gorillas, orangutans, and gibbons. The smallest of the apes is the gibbon, about the size of a New World monkey. They live in trees, feeding on fruit and leaves; they rarely come to the ground.

The orangutan is found today only in the Indonesian islands of Sumatra and Borneo. This ape has a long-haired coat of reddish fur. The orangutan inhabits tropical forests. It is similar to the gibbon in having long arms and long thin hands used to swing from limb to limb in the dense forest vegetation.

The gorilla is the largest of the apes; it is found in tropical and mountain forests of West and Central Africa. Though the gorilla lives in the forest and has the long arms of a tree-swinging ape, it is a terrestrial animal that walks using all four limbs, specifically the soles of the feet and the knuckles of the hands. Gorillas are herbivores, eating leaves, shoots, stems, and fruit.

The chimpanzee is also a terrestrial knuckle-walker, spending more time in the trees than the gorilla, often sleeping and feeding there. Chimpanzees sometimes leave the forest to range in open country. Their diet includes insects and some meat in addition to vegetable material.

Family Hominidae *Homo sapiens* is an entirely terrestrial primate whose ancestors left the forest and adapted to life on the open plains. The features which distinguish humans from the other primates are upright locomotion (bipedalism), regular manufacture and use of tools, and an omnivorous diet that necessitated hunting large and small animals.

Order Artiodactyla (170 species)
With the exception of the pig, these herbivores have complex stomachs of four compartments enabling them to digest plant materials; they are called ruminants. Each of the four legs ends in an even number of hooved toes.

Many animals in this group have horns or antlers. Some species are domesticated, such as pigs, cattle, sheep, goats, and camels. Other members of this group are hippopotamuses, giraffes, oxen, bison, and deer.

The orangutan swings through trees using its long arms. Another member of the ape family is the tool-using chimpanzee, able to walk on two legs.

Name ______________________________ Date ____________

Taxonomy 30
Kingdom Animalia

Subphylum Vertebrata, continued

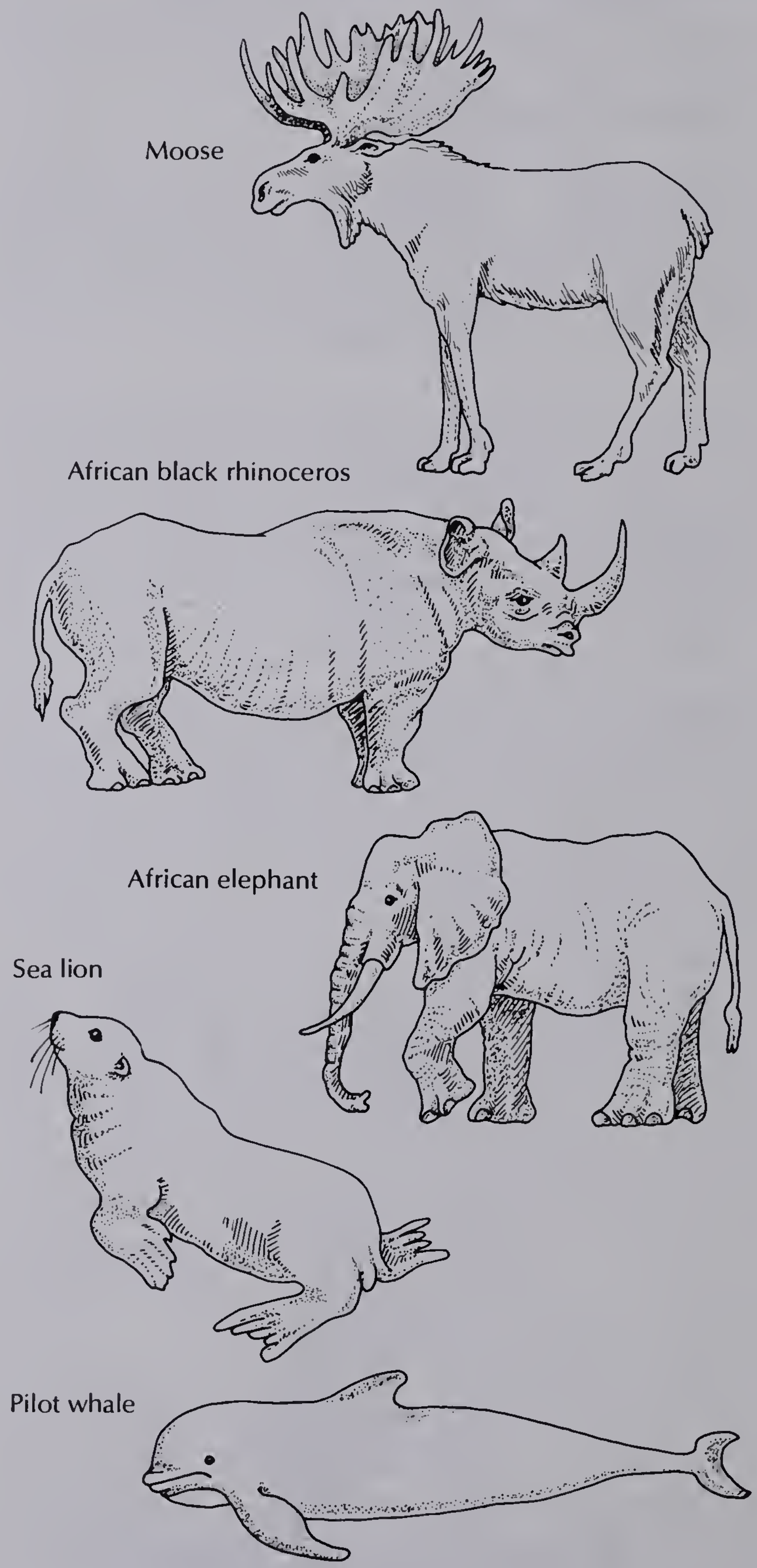
Order Perissodactyla (15 species)
In contrast to the artiodactyls, these large mammals have an odd number of hooved toes on each leg. They are herbivorous and have large, grinding teeth. They have a simple stomach. These hoofed mammals are native to Eurasia, Africa, and tropical America. Some examples are tapirs, rhinoceroses, horses, and zebras.

Order Proboscidea (2 species)
The elephants are herbivorous, with incisor teeth modified as tusks. The long trunk is a distinctive characteristic, as is the thick, sparsely-haired skin. Their diet consists of trees, grasses, and bamboos.

Order Pinnipedia
These aquatic mammals have a spindle-shaped body, limbs formed as flippers or paddles for swimming, webbed toes, and very short tails. They include the seals, walruses, and sea lions, which inhabit oceans and seacoasts, feeding mainly on fish.

Order Cetacea (80 species)
All cetaceans are aquatic, and most live in saltwater. Their tails are flattened horizontally, their front limbs are modified as flippers, and they have no hind limbs. No necks separate their large heads from their bodies. Their ear openings are very small and their nostrils are located on top of their head. The adults are hairless. Whales, dolphins, and porpoises are all cetaceans.

Order Sirenia (5 species)
These aquatic, herbivorous mammals have no hind legs; their paddlelike forelimbs and their wide tails aid in swimming. Their bodies are large and spindle-shaped. They have no external ears and are almost hairless. This order includes manatees, or seacows, and dugongs.



The moose, largest of all deer, annually sheds its flattened, bony antlers. The rhinoceros, nearly hairless, has continuously growing horns. The African elephant may weigh up to seven tons. The sea lion, an eared seal, lives along the Pacific Coast of North America. The pilot whale travels in schools behind a leader.

Answers

Reviews

Review Chapter 1

The Study of Living Things

1. Biology, zoology, botany.
2. Organism.
3. A biological species is a group of similar organisms that can mate with each other.
4. Cell membrane.
5. Directs the cell's activities.
6. Two or more cells.
7. It must obtain and use food, control its life processes, respond to the environment, and produce offspring.
8. Cells in a multicellular organism are specialized for different functions; a unicellular organism must perform all life functions.
9. It enables more efficient performance of particular functions.
10. Tissues, organ systems.
11. Stimuli.
12. Asexual reproduction involves one parent; sexual reproduction involves two parents.
13. Offspring of asexual reproduction more closely resemble their parent because their genes are identical to the parent's.
14. Ecology.
15. Producers, consumers.
16. Food chain.
17. Food web.
18. Plants need sunlight, water, and carbon dioxide in order to photosynthesize and produce their own food.
19. Decomposers.
20. Symbiosis.
21. Parasite.
22. Depend on the same resource, which is in short supply.
23. Ecosystem.
24. Biology is the study of living things by observation and testing.
25. Specialization of different cells for different functions would probably be the next stage.
26. Nerve signals are faster because they act to control adjustments that must be made quickly.
27. a. The population of mice will become smaller, and the fox will lose one food source.
    b. Without the fox to control it, the population of mice will grow larger.
28. Answers will vary, but must be of the form:
    producer ⟶ plant-eater ⟶ animal-eater ⟶ humans
29. Answers will vary but should include adaptations for feeding, moving, and reproducing.

Review Chapter 2

Classification of Living Things

1. Make a series of choices between two characteristics at each step in the key.
2. Common, scientific.
3. Taxonomy.
4. Species, genus, family, order, class, phylum, kingdom.
5. Binomial nomenclature.
6. Members of a species can mate with each other and produce offspring that also produce the same kind of offspring.
7. Genus, species.
8. Five-kingdom; monerans, fungi, plants, animals, and protists.
9. Moneran.
10. Neither has a true nucleus; a major difference is that blue-green algae have chlorophyll while bacteria do not.
11. Fungal.
12. They are producers; they have roots, stems, and leaves with vascular tissue; most tracheophytes live on land.
13. Seeds.
14. More than a million.
15. Sponges, Poriferan.
16. It is secreted by the mantle.
17. They have 8 legs, 2 body regions, and jointed exoskeleton.
18. They all have jointed exoskeletons.
19. A dorsal; hollow nerve cord, a notochord, and gill slits.
20. They live both in water and on land (aquatic and terrestrial).
21. Moist, dry.
22. Birds.
23. Two homologous structures are the human arm and bat wing. Two analogous structures are the insect wing and bird wing.
24. Animals having homologous structures are more closely related because the structures develop in the same way.
25. Plants contain chloroplasts; fungi do not.
26. Tracheophytes are best adapted for life on land. Adaptations for land include roots, stems, and leaves with vascular tissue; in addition they reproduce by seeds or spores.
27. Both have bodies made of two cell layers, and digestive tracts with only one opening.
28. They have the basic chordate characteristics; humans are also chordates.

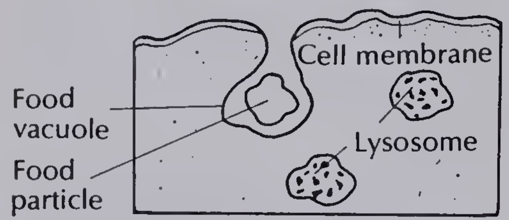
Review Chapter 3

The Cell: Basic Unit of Life

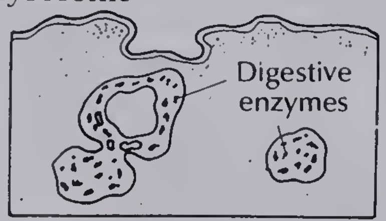
1. Robert Hooke, Antony van Leeuwenhoek.
2. Compound microscopes have two or more lenses; simple microscopes have only one lens.
3. Illuminate it by turning the mirror toward a light source, or by turning on a built-in light source.
4. Electron microscope, 100 000.
5. Living, unstained material can be studied through a phase microscope.
6. Micrometre.
7. Cytoplasm.
8. A possible explanation of observations.
9. Organelles.
10. Control, experiment.
11. Division of labor.
12. Lipids.
13. It acts as a barrier to some

molecules and is permeable to others.

14. Plants, fungi, and monerans.
15. Fibrous, plants.
16. Nucleus.
17. Pores.
18. Nucleic acids, protein.
19. Chromosomes contain hereditary information that directs all cell activities.
20. *Mitochondrion:* production of ATP; body of shelflike structures.
    Golgi apparatus: packaging of materials; made of membranes.
    Endoplasmic reticulum: transport of cell substances; system of membranes.
    Chloroplast: photosynthesis; layered.
    Vacuole: storage; saclike.
    Microfilaments and microtubules: strength and shape; threadlike or tubular.
    Ribosomes: protein assembly; beadlike.
    Lysosome: digestion; membrane-covered bodies.
21. Nucleolus, eukaryotic.
22. Smooth, rough, Golgi apparatus.
23. In the scanning electron microscope, electrons bounce off the surface of the object. In the electron microscope electrons pass through the object.
24. A cell cannot live without eliminating some substances and retaining others.
25. a. Food vacuoles formed

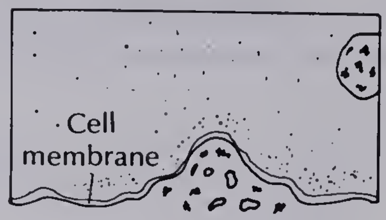


    b. Fusion of vacuole with lysosome



    c. Breakdown of food by enzymes

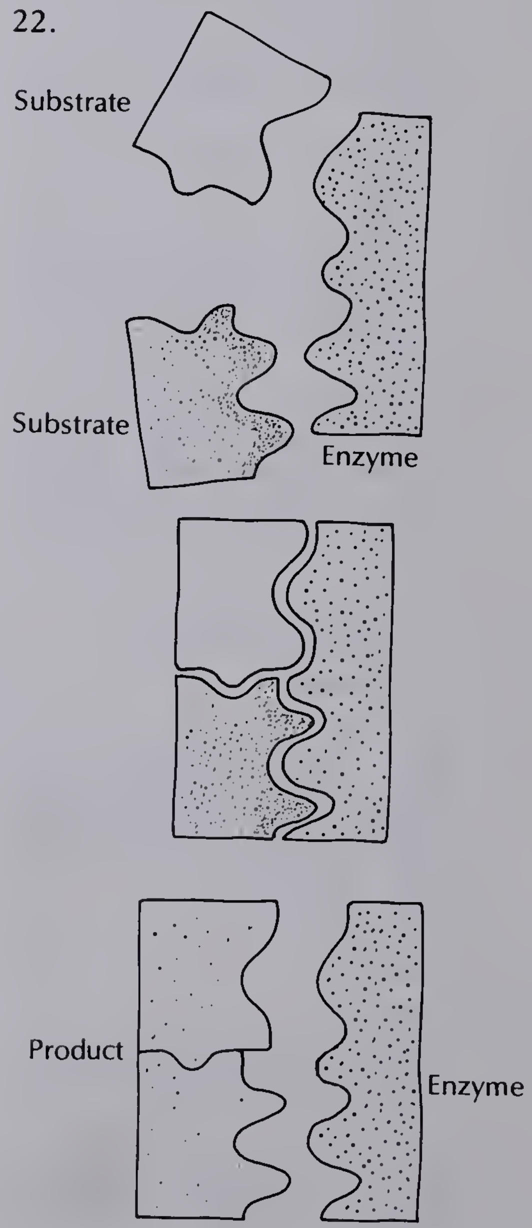
    d. Expulsion of undigested food at cell membrane



26. A muscle cell contains more mitochondria because more energy is used in muscle contraction.
27. In cilia microtubules produce swimming movements. In the cell microtubules change the cell's shape.
28. Endoplasmic reticulum, chloroplast, mitochondrion, Golgi apparatus, cell membrane.
29. Release of enzymes from cell membrane.

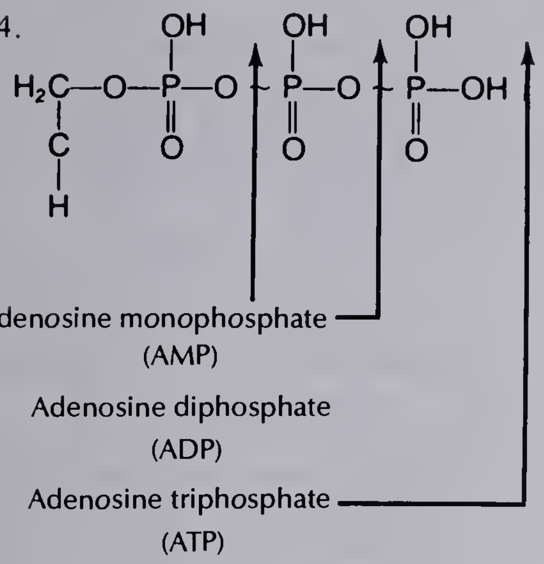
Review Chapter 4
The Molecular Machinery of the Cell

1. Atom, nucleus, protons, neutrons, electrons.
2. a. An atom or group of atoms having a charge because of a loss or gain of electrons.
   b. A group of atoms combined, always in the same proportions, to form a definite substance.
   c. A bond formed by the sharing of electron(s) by two or more atoms.
   d. An atom or group of atoms (alike or different) combined. It has a neutral (zero) charge.
3. Covalent bonds.
4. Bonds are broken, atoms are rearranged, and new bonds are formed during a chemical reaction.
5. Centrifuge.
6. Chromatography, molecules.
7. Sugars, monosaccharides, glucose, fructose.
8. Glycogen.
9. Amino acids.
10. a. Has fatty acid having a double bond between carbon atoms.
    b. Has fatty acid having more than one double bond between carbon atoms.
    c. Has fatty acid having only single bonds between carbon atoms.
11. Answers will vary. Example:
    Fats: butter; forms cell membrane material, food storage.
    Carbohydrates: rice provide energy, food storage.
    Proteins: meat; growth and repair of cells.
12. Sugar, phosphate, base.
13. Kinetic energy is the energy of motion.
    Potential energy is stored energy.
14. Energy required to start chemical reactions.
15. Enzymes, protein.
16. Substrates, products.
17. Synthesis.
18. Dehydration, hydrolysis.
19. H   H   H-hydrogen
      O   O-oxygen
20. An ionic bond is being broken.
21. Heat destroys the weaker linkages, causing the protein to uncoil.
22.



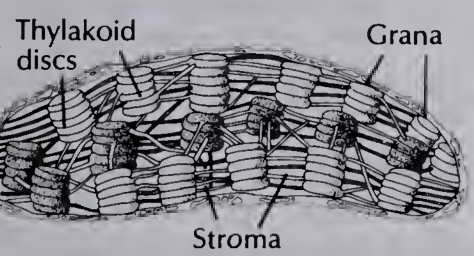
Each enzyme fits specific substrates, as a key fits certain locks. It brings them together so they can react.

23. O° C is the optimal temperature for enzyme a; arctic fish.
    30° C is the optimal temperature for enzyme b; rat.
24.

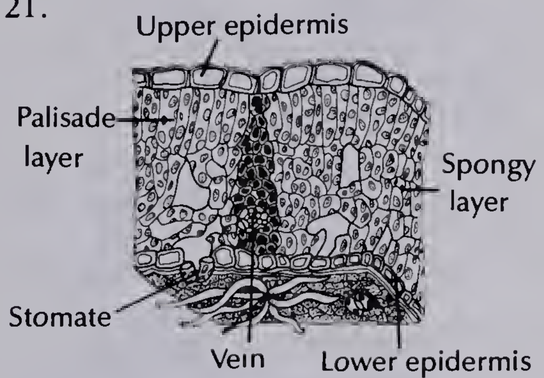


Review Chapter 5
Food Production and Nutrition

1. Carbon dioxide, water, glucose, oxygen.
2. Epidermis, palisade layer, and spongy layer.
3. Water is transported through veins in the spongy layer.
4. Guard cells open and close the stomates.
5. Pigment, reflecting.
6.



7. ATP, NADPH.
8. ADP, phosphate.
9. Transfer of electrons, protons, and energy.
10. Absorption of light energy causes it to become "excited."
11. Proteins, carbohydrates, lipids, vitamins, and minerals.
12. Nonessential nutrients can be synthesized from other substances. Essential nutrients must be obtained from food.
13. There are eight essential amino acids. One of the following as an example: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine.
14. Answers will vary. Refer to page 169 of text.
15. Water acts as a solvent for body fluids and functions in transport of materials, regulation of body temperature, and chemical synthesis and hydrolysis (any two answers).
16. Calorimeter.
17. The quantity of heat required to raise one kg of water 1°C.
18. Answers will vary. Refer to page 171 of text.
19. Three of the following: breathing, maintaining body temperature, cell functioning, blood circulation.
20. Uptake of water by the plant was causing the water loss.
21.



    Most photosynthesis occurs in the palisade layer. Most CO_2 uptake occurs in the stomates.
22. Guard cells open and close the stomates to control water loss. This also controls uptake of carbon dioxide and thus affects photosynthesis.
23. Go to end of Reviews answers.
24. Mammals and birds have a higher metabolic rate because they must maintain a high body temperature that affects chemical reactions by speeding them up.

Review Chapter 6
Obtaining Energy from Food

1. Energy, food.
2. It is stored as ATP.
3. a. Sunlight is the source in photosynthesis.
   b. Glucose is the source in cellular respiration.
4. A series of chemical reactions in a biological process.
5. Glycolysis, citric acid cycle, and electron transport.
6. It is anaerobic; the other two are aerobic.
7. Mitochondrion, cristae.
8. Anaerobic oxygen.
9. Each is split into 2 molecules of pyruvic acid, with the release of energy.
10. Energy, carbon dioxide.
11. Lose, ATP.
12. O_2; ADP, H_2O, ATP.
13. Lactic acid, ethanol and carbon dioxide.
14. 36, more.
15. Lipids yield twice the energy per gram. It is stored as fat.
16. Obtaining and using energy.
17. Active, energy.
18. The smaller the mammal, the greater the basal metabolic rate.
19. They go into hibernation.
20. Body functions and metabolic rate are slowed with decreasing temperature. For example, crickets sing more slowly at lower temperatures.
21. It increases their rate. Energy is stored as ATP, then used as needed.
22. Photosynthesis begins with carbon dioxide and water, and uses sunlight's energy to produce glucose and oxygen. Energy is stored as ATP, and chloroplasts are the organelles.
    Respiration is just the opposite in terms of starting and end products: glucose is combined with oxygen to form carbon dioxide and water, with ATP supplying the energy and heat being given off. Cellular respiration takes place in mitochondria.
23. It uses up all the oxygen and replaces it with carbon dioxide.
    a. It will live a longer time.
    b. The mouse will die quickly in this case.

    Plants use up the excess carbon dioxide and provide oxygen; but when the container is covered, photosynthesis cannot take place because sunlight cannot reach the plants and oxygen is not produced.
24. They store energy as fat which also serves to insulate the body against cold temperatures. Most have a body covering of hair, fur, or feathers also.

Review Chapter 7
Gas Exchange

1. Respiration refers to the exchange of oxygen and carbon dioxide through cell membranes. Cellular respiration refers to the synthesis of ATP, using energy in food. Breathing refers to inhaling and exhaling of air by an animal.
2. a. The organism takes in oxygen through a moist membrane.
   b. Oxygen is transported to all parts of the body.
   c. Carbon dioxide is transported from the body to the same moist cell membranes through which oxygen enters.
   d. Carbon dioxide is expelled through the moist cell membrane.
3. Stomates.
4. Photosynthesis, cellular respiration.
5. A stomate is surrounded by guard cells, which pull apart when water pressure inside them increases, opening the stomate.
6. There is no cuticle covering the roots; gas exchange takes place directly across outer root cell membranes.
7. Oxygen moves directly into the cells of each of the two cell layers, and carbon dioxide moves directly out.
8. Skin, mucus.
9. Spiracles, tracheas, air sacs.
10. Oxygen transport to all cells of the body.
11. Hemoglobin, oxygen.
12. Homeostasis refers to the ability of the body to maintain a balanced internal environment. In respiration, homeostasis controls levels of oxygen and carbon dioxide by adjusting breathing rate and volume of air inhaled.
13. Respiratory, carbon dioxide.
14. Go to end of Reviews answers.
15. a. Gases have farthest to travel in the annelid. Gas exchange takes place at the surface of moist skin.
    b. The platyhelminth has more surface area due to its flattened shape.
16. Both oxygen and carbon dioxide move from areas of less concentration to areas of greater concentration—the oxygen from alveoli into the blood capillaries, and the carbon dioxide from capillaries into the alveoli.
17. The warmblooded animal will use more oxygen and thus require a larger surface area for gas exchange because it continually uses oxygen to convert food to energy to maintain a high body temperature.
18. On a hot, dry day the stomates would close, conserving the plant's water and slowing the rate of photosynthesis by taking in less carbon dioxide.

Review Chapter 8
Food Processing

1. They obtain food.
   They break food down into nutrients.
   They absorb and deliver nutrients to the body.
   They eliminate food wastes.
   They use and store nutrients.
2. Food vacuole; digestive tract.
3. Ingestion.
4. In mechanical digestion large chunks of food are broken down to small chunks by mechanical processes such as biting or grinding.
   In chemical digestion, large molecules are broken down to small molecules in chemical reactions.
5. a. Protease.
   b. Lipase.
   c. Amylase or maltase.
   d. Nuclease.
6. a. Maltose.
   b. Glucose.
   c. Amino acids.
   d. Fatty acids and glycerol.
   e. Nitrogen bases and simple sugars.
7. Intracellular, extracellular.
8. Absorption, egestion.
9. Oral groove, anal pore.
10. Nematocysts; stinging cells are used to paralyze prey.
11. Crop, gizzard, intestine.
12. Mechanical, stomach, chemical.
13. Mouth, esophagus, stomach, small intestine, large intestine, and anus.
14. Bile, pancreatic juice, and intestinal juice.
15. Microvilli.
16. Nerves, hormones.
17. They absorb material digested by their hosts.
18. It probably contains digestive enzymes.
19. a. She needs protein for producing and nourishing eggs.
    b. Glucose can be obtained from plants.
20. In the earthworm's system, all the events of digestion can occur at once. In the hydra, egestion can interfere with ingestion since both take place at the same surface.
21. It would slow down the process of digestion, particularly protein foods that are best digested in an acidic solution.
22. The rabbit, because it is herbivorous and requires a long digestive tract to break down fibrous plant material.
23. Probably the animal would lose weight first, then eat more. The brain would not receive signals to produce gastric juice, which would interfere with digestion of proteins; the body would react to this lack of nutrients by requiring more food intake.

Review Chapter 9
Transport

1. Greater, lesser.
2. Diffusion, semipermeable.
3. b.
4. Passive, active, water, less, water.
5. Root pressure, capillarity, and transpiration are the three processes.
6. b, open; a, c and d, closed.
7. a and c, yes; b and d, no.
8. Go to end of Reviews answers.
9. increased heart rate: b
   dilation of skin capillaries: a
   dilation of arteries and decreased heart rate: d
   dilation of arteries to gut: c
10. The nervous and circulatory systems are directly involved.
11. As muscles work harder they require more oxygen and nutrients; these are supplied by

increased blood supply to the muscles.

12. It moves essential substances to, and removes toxins from, all cells.
13. In a double circulatory system each contraction of the heart sends blood through both systems simultaneously, enabling gas exchange to take place in more cells of the body at one time.
14. Trees move water from the soil into the xylem and then into the air through evaporation through lenticels and stomates. Stomates in the leaves may close to prevent water from escaping, keeping a column of water present in the tree despite hot, dry air surrounding it.

Review Chapter 10
Excretion

1. Amino acids in protein.
2. Go to end of Reviews answers.
3. Uric acid, water.
4. Carbonic acid, acidic, enzyme.
5. Lose, take in, excrete, large, absorb.
6. Carbon dioxide.
7. Contractile vacuoles, water.
8. Nephridia.
9. Malpighian tubules, osmosis, active transport.
10. Lungs, salts, water, urea, kidneys, urine.
11. Water, permeable, more, concentrated.
12. They are adapted to be able to hold a concentration of water inside the body that is similar to the concentration of water in the ocean; thus, there is no movement of water by osmosis.
13. During the day they use carbon dioxide for photosynthesis.
14. a. They are analogous. Nephrons are units of the vertebrate excretory organ, the kidney. Like nephridia, they perform the functions of collection and excretion of wastes, and are well shaped for their function.
    b. Go to end of Reviews answers.
    c. The Bowman's capsule acts as a barrier preventing protein loss from the blood in vertebrates. In the earthworm the nephridia filter all of the body fluid, separating wastes and returning useful material such as water, sugar, and salts.
    d. Blood pressure forces the wastes to diffuse into the Bowman's capsule.

Review Chapter 11
Movement and Locomotion

1. Protein threads, contraction.
2. Flagella, microtubules, microtubules.
3. a. Planarian.
   b. Euglena.
   c. Sponge, coelenterate, or other flagella-bearing animal.
4. Pseudopods.
5. Plants move by means of turgor movements, caused by changes in water content in some cells.
6. They pull against the fluid-filled body.
7. Nerve, contractile, body wall, tentacles.
8. Shorten, elongates.
9. Head, thorax, abdomen.
10. Appendages.
11. Go to end of Reviews answers.
12. *Skeletal:* striated, voluntary, fast.

    Smooth: unstriated, involuntary, slow.

    Cardiac: striated, involuntary, fast or slow.
13. Mitochondria supply the muscle fibrils with ATP. Blood supplies the mitochondria with oxygen.
14. Nerve impulses. Hormones, nerves.
15. As muscles deplete the supply of oxygen they switch to anaerobic respiration, a fermentation process that produces lactic acid as a by-product. As the muscle continues to be used, lactic acid accumulates and reduces the ability of the muscle to contract.
16. a. Exoskeleton.
    b. Arthropod.
    c. Muscle a.
    d. Muscle b.
17. The exoskeleton cannot grow, and it limits the animal's size. Molting is an adaptation that enables the organism to grow and produce a new, larger exoskeleton.
18. The legs are extended by contracting the abdominal muscles, forcing fluid from the body into the legs.
19. The bone marrow can produce healthy new blood cells.

Review Chapter 12
Chemical Control

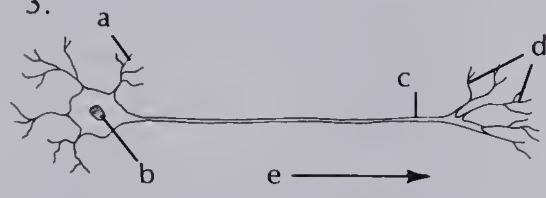
1. Hormones are chemicals that regulate body functions in complex plants and animals.
2. Specialized cells produce the hormone. The hormone is transported through the body to a target structure. The hormone functions to trigger a chemical reaction to regulate the activity of the target structure.
3. Growing.
4. Cytokinin, auxin, abscissic acid; leaves, fruit, drop off.
5. Auxin, light.
6. Ductless, target.
7. Membranes, inside.
8. Recognized, cyclic AMP, second signal.
9. Molting, molting.
10. Follicle stage, ovulation, and corpus luteum.
11. Menstruation, pregnancy.
12. Chemical feedback. Immediately following testis removal there is decreased level of testosterone. Decreased testosterone stimulates the pituitary to increase gonadotropin secretion. This, in turn, stimulates growth of the remaining testis. Eventually there is a return to the original level of sperm production.
13. In a diabetic glucose cannot be metabolized because of the lowered insulin level. Thus, the person feels deprived of nutrients and is starved. Increased urination caused by this disease can result in dehydration. Insulin is given as a drug to replace insulin not being produced by the body.
14. (Any three:) *Progesterone* is produced in the placenta and corpus luteum (ovary); it maintains the uterine wall.

Estrogen is produced in the placenta; it helps maintain the uterine wall.
Oxytocin is produced in the hypothalmus; it stimulates uterine muscular contraction.
Prolactin is produced in the anterior lobe of the pituitary; it stimulates mammary glands.

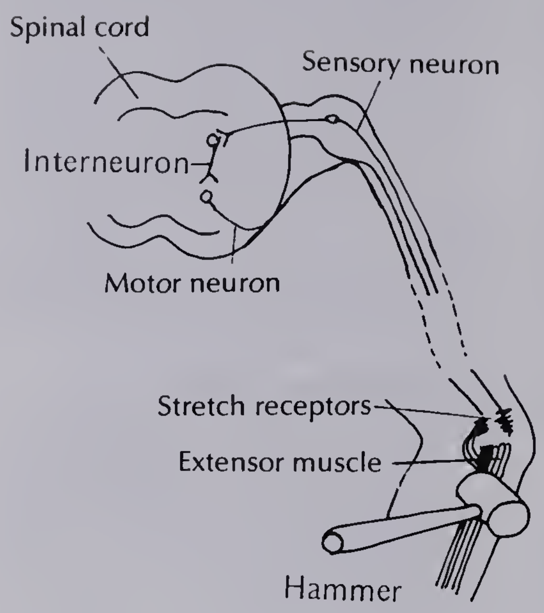
15. The egg must travel down the oviduct to the uterus and become attached to the uterine wall. This requires that the corpus luteum not disintegrate, but continue producing progesterone.

Review Chapter 13
Nervous Control

1. Sensor, environment.
2. Effector.
3.



4. Sensory, motor, interneurons.
5. Lower, potassium, negatively, negatively.
6. Sodium, positively, nerve impulse.
7. A hydra lacks a central nervous system for impulse coordination. As a result, its behavior is slow and limited; impulses spread out from the point of stimulation of the nerve net.
8. Contraction of muscles in one segment stimulates the sensory neurons in the next segment. Sensory neurons send impulses to ganglia; motor neuron impulses stimulate the muscles in the next segment, and so on.
9. Ganglia.
10. Involuntary; digestion, respiration, heartbeat.
11. Acetylcholine.
12. Opposite, slow down, speed up.
13. Motor unit.
14. a. It will be the same.
    b. Levels of acetylcholine will increase.
    c. permeability will be increased for a longer time.
    d. Rate and duration of the impulse will increase.
15.



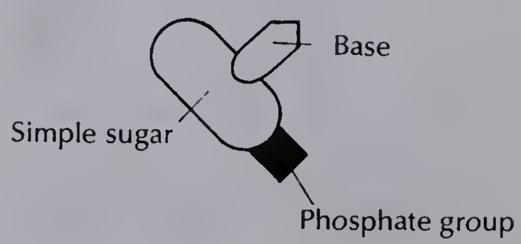
16. The sodium pump removes sodium ions from the cell and transports potassium ions into the cell by active transport. The sodium pump helps maintain the polarized state of the resting cell membrane.

Review Chapter 14
The Senses

1. *Mechanoreceptor:* touch, pressure, vibration.
   Photoreceptor: light.
   Thermoreceptor: heat.
   Proprioceptor: body movements or position.
2. Answers may include examples such as: infrared (heat) detected by snakes; ultraviolet (light) detected by bees; polarized light, detected by bees; ultrasound detected by dogs, dolphins, bats; water current motion detected by fish.
3. Response, neuron. It depends on which brain center receives the sensory impulse.
4. Bats. Bats emit ultrasound cries that are reflected back for detection. They use echolocation to locate prey.
5. It enables them to locate the sun and maintain their bearings in locating food and communicating its location to other bees.
6. Tympanic membrane.
7. Anvil, stirrup, middle, inner, oval window.
8. Cochlea. Fluid in the cochlea vibrates in waves, causing the hair cells to bend, which stimulates neurons. Nerve impulses are then carried to the brain via the auditory nerve.
9. Lens compound, facets, ommatidium. A simple eye is able to focus one image. A compound eye forms many images and is able to perceive motion but cannot focus.
10. It focuses by a lens that adjusts for distance of the object viewed. Both produce an inverted image on a light-sensitive surface.
11. Sclera, cornea. Light is focused by bending.
12. Chemoreceptors, bitter.
13. Retina. Cones are used in bright light, rods in dim. Color is less evident; we see in shades of grey.
14. Rhodopsin that was broken down in light is being regenerated in the rods. Gradually the retina becomes more sensitive to the smaller amount of light.
15. Since their prey are cold-blooded, they emit no heat; thus, thermoreceptors in these snakes would be useless.
16. Fish. Smell is a leading sense because visibility in water is less than in air.
17. The fluid inside is set in motion in all directions, pushing a doorlike structure that bends hairs in the hair cells, which stimulates sensory neurons.
18. The same thermoreceptors are stimulated in either case.
19. Wolf spiders. They actively search for prey and must be able to spot prey in the distance.

Review Chapter 15
Reproduction of Molecules and Cells

1. Nitrogen, thymine.
   a. Adenine pairs with thymine; cytosine pairs with guanine.
   b. Uracil replaces thymine.
2.



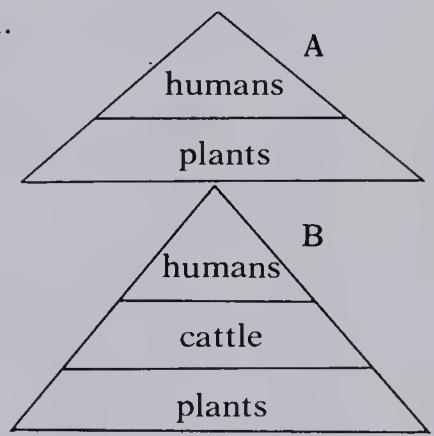
Review Chapter 20
Heredity, Chromosomes and Genes

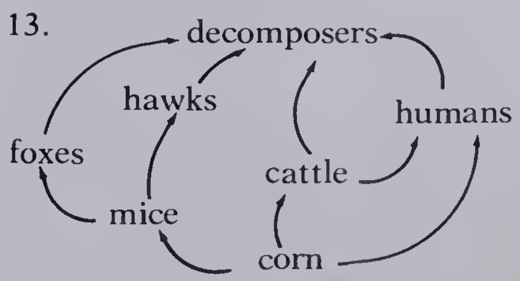
1. Chromosomes, homologous, homologous, X, Y.
2. It is located on the X chromosome.
3. Nondisjunction.
4. Chromosomal, gene.
5. Chromosomal, gene.
6. b.
7. Mutagens. Examples may include mustard gas, radiation, X-rays, and colchicine.
8. Polyploid, mutation.
9. Alleles, locus.
10. Fruit flies, gene map, greater.
11. Nondisjunction, separate.
12. F. Griffith, gene, deoxyribonucleic acid (or DNA).
13. Beadle and Tatum, gene, enzyme. A gene controls production of an enzyme.
14. This is genetically controlled by many genes affecting the expression of the same trait. Environmental influences is the other factor involved.
15. Baby Y belonged to Mother 1; Baby X to mother 2.
16. The mother's antibodies attack the baby's antigens. This can lead to destruction of the baby's blood cells so that the baby's blood must be replaced by transfusion. In addition, oxygen cannot be transported without the aid of the blood cells, leading to respiratory failure.
17. A child having PKU cannot produce the enzyme that changes phenylalanine to tyrosine. This is due to mutation of the gene that codes for the enzyme needed to convert phenylalanine.
18. This is termed genetic engineering. Bacteria are chosen because they reproduce quickly and are easy to culture in the laboratory and can produce large quantities of insulin.
19. The probability is 10 percent. Both males and females have an equal change of inheriting the gene. Since the trait for white eyes is sex-linked, it is expressed in all the males receiving the X chromosome carrying this gene; in females the trait is carried, but not expressed.

Review Chapter 21
Change Over Time

1. Abiogenesis.
2. Active principle.
3. A sealed jar prevented air from entering; air was considered necessary for abiogenesis. Lack of air would kill the active principle in meat or fish. Using a screen allowed in air, but not flies.
4. Bacteria in the dust that collected in the curved part of the flask were washed into the sterile broth, where they multiplied. This experiment disproved the theory of abiogenesis.
5. Non-photosynthesizing organisms arose first. Heterotroph hypothesis.
6. Photosynthesis by autotrophs released oxygen into the atmosphere.
7. Some of the oxygen produced by autotrophs rose high into the atmosphere to form the ozone layer. It shields them from ultraviolet radiation.
8. a. Water, hydrogen, ammonia, and methane. Yes, as far as is now known.
   b. They used an electric spark. Organic compounds, including amino acids formed as products.
9. Fossils.
10. Radioactive, nonradioactive.
11. The clues suggest relationships among species and show that changes have occurred in species over time.
12. Evolution.
13. Use, disuse.
14. Theory of natural selection.
    a. More organisms are born than can survive.
    b. Variations in organisms aid in their survival.
    c. Organisms with favorable variations survive and reproduce.
15. c.
16. Fossil ferns could be expected to be found in the rock dating to the Carboniferous period, dinosaur fossils in the rock from the Jurassic period. Ferns are fossilized as imprints in carbon rock. Dinosaur skeletons become mineralized into stone while buried in mud sediment.

Review Chapter 22
Interactions in the Ecosystem

1. Go to end of Reviews answers.
2. Primary, chain.
3. Food web.
4. Decomposers are not included in energy pyramids. Chemical energy is represented. At all levels energy in the form of heat is lost.
5. Condensation, water.
6. It returns as carbon dioxide. It is reintroduced during photosynthesis by producers.
7. Fixation, bacteria, bacteria, nitrification, protein.
8. Symbiotic, competition.
9. Predation: One organism preys on another.
   Mutualism: Both gain some advantage.
   Commensalism: One gains benefit, one is unaffected.
   Parasitism: One benefits at the other's expense.
   Competition: The organisms are rivals for resources.
10. a.


    b. A.
11. These crops are legumes which have nitrogen-fixing bacteria that act to restore nitrogen to the soil.
12. a. Corn ⟶ Mice ⟶ Foxes
    b. The mice population will increase in number.
    c. More of the corn produced will be consumed by the larger number of mice.
13.


14. a. Commensalism.
    b. Mutualism.
    c. Predation.
    d. Parasitism.

Review Chapter 23
Populations in Ecosystems

1. Organisms, species.
2. Explosion, crash. It would show an S-shaped curve.
3. Factors that limit population growth.
4. Slow growth as population becomes established, rapid growth, growth levels off.
5. Carrying capacity.
6. Dynamic refers to the fact that the population size and composition is continually changing. Equilibrium refers to the factors in an ecosystem working to maintain balance between population size and carrying capacity.
7. Density.
8. Birth, death, immigration, and emigration rates measure changes in a population.
9. Death, emigration. Birth, immigration.
10. 6.
    a. Lower death rate is the major factor.
    b. Agricultural and medical advances and technology have contributed.
    c. Availability of food. The carrying capacity of the environment is related to the amount of food that can be provided for the human population.
11. a. The space was used up and crowding contributed to growth decrease.
    b. It is a J-shaped curve. Population crash is the term to describe this change.
12. a. The population of algae will decrease.
    b. The daphnia population will increase.
    c. Curve A represents algae; Curve B represents daphnia.
13. a. It might start up from immigration of new individuals into the area.
    b. The immigration rate was higher.
    c. The emigration rate was higher.
    d. 1978.

Review Chapter 24
The Geography of Ecosystems

1. Original.
2. Wind, water. Animals can run, fly, or swim, or be carried on rafts or other animals. Plants can be carried on animal fur or in feces.
3. b.
4. Habitat, niche. Environmental change can cause both factors to change.
5. Pioneers, climax.
6. Ecological succession.
7. Protozoa and algae may enter from the air, incoming water, or nearby soil. Birds and animals bring seeds. Insects are attracted to the water. Birds fly in, animals come from nearby areas, fish enter from nearby streams.
8. Decomposition of dead organisms and sedimentation are the two sources.
9. a. Desert, tundra, tropical rain forest.
10. Tropical rain forest.
11. Rainfall. Answers will vary. Examples are antelope (herbivore) and lion (predator); prairie dog (herbivore) and coyote (predator).
12. 60 days, dark, permafrost. Moss or lichen; musk ox, caribou, or reindeer.
13. Moisture, 15, rain. Cactus: desert shrubs, armadillo, kangaroo rat, pocket mouse, and desert birds are examples.
14. In the coniferous forest you would find wolves and moose. A deciduous forest would have this amount of rainfall.
15. A slow-moving stream will have more producers, called phytoplankton.
16. Estuaries would contain salt-tolerant plants.
17. a. The first, pioneer species. Pioneer plants often must subsist on bare soil that lacks nutrients from decayed matter, as well as water normally held by plants. Pioneer animals must survive without the nutrients provided by a large number of other organisms.
18. Both will have grasses, mosses, lichens, small flowering plants, and shrubs. They may have musk oxen, caribou, reindeer, and small mammals. In both environments the plants and animals must be resistant to cold and wind. They are both characterized by severe cold and a short growing season. The first environment is called a life zone; the second is termed a biome.
19. a. 1, 2, 3.
    b. Sunlight cannot penetrate that far.
    c. They consume decomposing material filtering down from above.
    d. Rising currents of water bring nutrients to the surface.

Review Chapter 25
Behavior

1. a. Learned.
   b. Inherited.
   c. Inherited.
   d. Learned.
2. Tropisms, phototropism.
3. Kinesis, taxis. Locomotion is involved in both.
4. Reflex.
5. Instincts.
6. Releaser.
7. Learning.
8. Habituation, conditioned.
9. Memory.
10. Diurnal, diurnal, nocturnal.
11. Migration.
12. Reinforcer, operant.
13. Photoperiodism.
14. No. They must be exposed to a certain uninterrupted period of darkness.
15. Circadian.
16. Konrad Lorenz, imprinting.
17. Pheromones.
18. Queens, drones, workers. Queens and drones are able to reproduce. Workers perform a waggle dance to communicate to the other bees in the hive the location of food more than 100 metres from the hive.
19. Real fighting would be a

waste of valuable energy and would result in death or injury.

20. This behavior is inherited and is called an instinct.
21. a. Withdrawal of the gill will cease.
    b. Habituation is the term for this kind of learning.
    c. Gills will be withdrawn. This form of learning is called classical conditioning.

Review Chapter 26
Health and Disease

1. Malfunction.
2. Immune, disease.
3. Any three examples, such as pollution, diet, or stress.
4. Cancer, emphysema, and heart disease are the main causes.
5. Emotion, physical.
6. They are classified as drugs. Barbiturates induce sleep; amphetamines keep a person awake.
7. Pathogens.
8. Epidemic. Any example, such as the twelfth century plague or influenza.
9. Bacteria. Some examples are: Virus: viral pneumonia, chicken pox. Protozoa: African sleeping sickness.
10. As spores.
11. Toxins.
12. Virus. Any example, such as flu, pneumonia, or common cold.
13. Trypanosomes, blood; It picks them up from blood ingested from infected hosts.
14. Mosquito.
15. Fungi; They are dispersed and transmitted as spores.
16. Antibodies, lymphocytes.
17. Vaccination; The third line of defense, the immune system, is activated.
18. Germ, Joseph Lister.
19. Identify.
20. No, they are transmitted by genes that are inherited.
21. Stress and improper diet are the two main factors.
22. In order to prevent spread of this contagious disease I would not let the sufferer prepare food or beverages for the family; personal articles should be kept separate; sneezes and coughs should be covered; personal contact with the infected person should be avoided.
23. I would suspect a tapeworm. It absorbs nutrients from food ingested by the host and deprives the host of necessary nutrients.
24. The cyclical, massive release of spores that simultaneously attack and kill red blood cells.
25. It would increase since infection stimulates bone marrow to produce large numbers of white blood cells to fight the infection.

Review Chapter 5, Question 23

	Light reactions	Dark reactions
Energy source	Sun or other light source	ATP
Inorganic compounds	Water, phosphorus	Water and carbon dioxide
Products	ATP, NADPH	Glucose

Review Chapter 10, Question 2

Type of waste	Toxicity	Solubility in water	Example (Answers will vary)
Ammonia	H	H	Ameba
Urea	M	H	Impala
Uric acid	L	L	Snake

Review Chapter 11, Question 11

Skeletal material	Physical properties	Structure in which it is found
Bone, compact	Heavy, no spaces	Along length of bone
Cartilage	Large, rounded cells; firm, flexible matrix	Tip of nose, outer ear, trachea, bronchi
Ligament	Strong, elastic	Joints of bones
Tendon	Strong, inelastic	Connections between bone and muscle

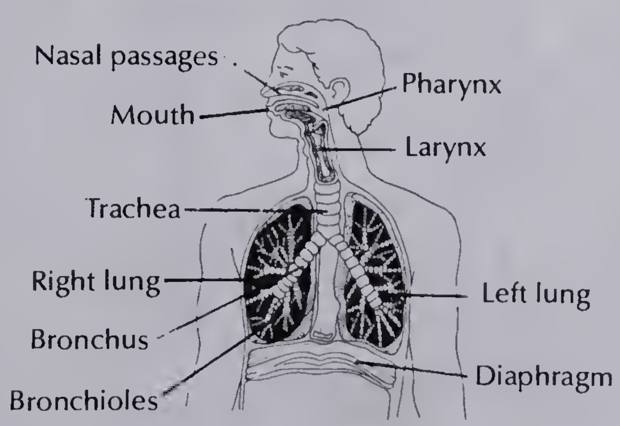
Review Chapter 15, Question 10

	DNA	RNA
Number of strands	2	1
Simple sugar	deoxyribose	ribose
Nitrogen base not shared	thymine	uracil
Area of cell	nucleus	cytoplasm

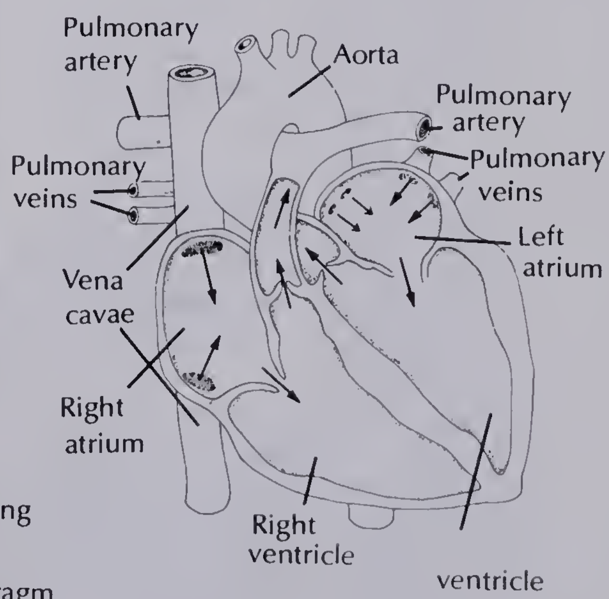
Review Chapter 22, Question 1

Producers	Consumers	Decomposers
Algae	Humans	Bacteria
Oak tree	Rabbits	Slime mold
	Paramecium	

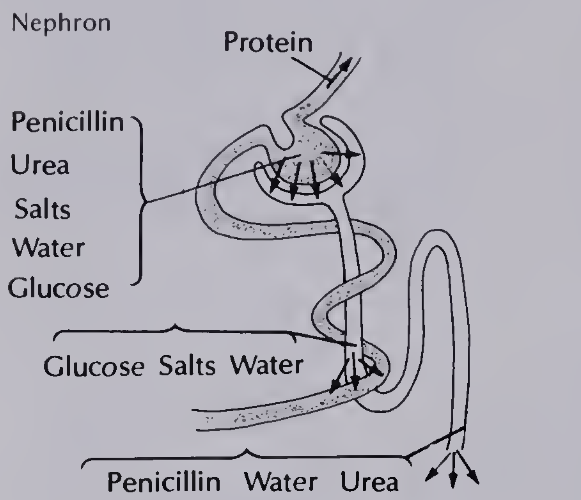
Review Chapter 7, Question 14

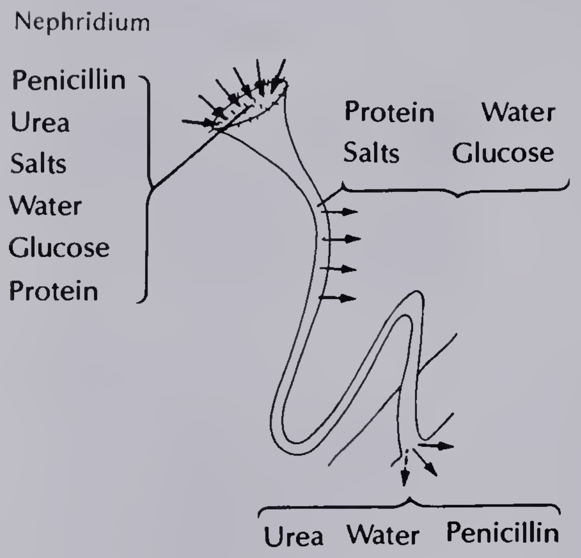


Review Chapter 9, Question 8

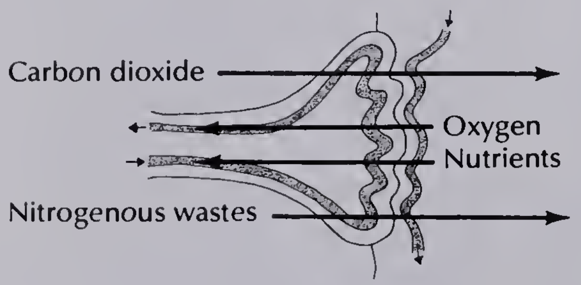


Review Chapter 10, Question 14, b.





Review Chapter 18, Question 5



Study Skills

Study Skill 1
Reading About Biology

1. That Earth's atmosphere could change to become like that of Venus if oxygen is depleted and all life on Earth is destroyed.
2. That Earth may suffer the same consequences of pollution that Venus may have suffered due to pollution of the atmosphere by the burning of fossil fuels.
3. From the fact that lethal gases such as carbon monoxide have been recorded on Venus, it does not necessarily follow that this was caused by pollution; there may have been other sources of these gases.
4. No; there is no data to support the idea of a once flourishing civilization on Venus. No alternative interpretations of the data are offered. The conjecture that "probably" signs of a once flourishing civilization will be found on Venus is not supported by any data; it is simply the author's own belief.
5. The author assumes ("believes") that Venus was once inhabited by living organisms and had a civilization. A strong bias against the burning of fossil fuels and production of pollutants is expressed.
6. "use of the atmosphere as a garbage dump"; "information that flabbergasted the scientific community"; "our magnificent planet Earth"
7. Yes. The fact that pollution due to burning of fossil fuels is altering the gaseous composition of Earth's atmosphere is a real concern. The author may be overstating the case in saying that "soon there will be no more oxygen in Earth's atmosphere."
8. Answers will vary. Assume that the reader will decide not to read to the end because the author's arguments are not sound enough to encourage reading further to be convinced of the author's conclusions. The reader may disagree based on knowledge of how Venus was probably formed and how its atmosphere was formed. The reader may disagree with conclusions drawn about pollution causing a complete depletion of oxygen in Earth's atmosphere based on knowledge about the "greenhouse effect" and increased capacity of plants to produce oxygen.

Study Skill 2
Understanding Biological Terminology

(Sentences based on word meanings will vary.)

1. ab- = away from,
   -normal = normal
2. ame- = change, -ba = life
3. aero- = air, -be = life
4. exo- = outside,
   -skeleton = skeleton
5. endo- = within, -derm = skin
6. hyper- = over,
   -tension = tension
7. hypo- = below,
   -thermia = heat
8. in- = not,
   -organic = organic
9. meta- = change,
   -phase = phase
10. ovi- = egg,
    -duct = duct, (canal)

(Definitions Exercise)

(Sentences based on word meanings will vary.)

1. anti- = against, body = body
2. chromato- = color,
   graph = write
3. chemo- = by chemicals,
   therapy = nurse, care
4. chromo- = color,
   some = body
5. de- = down,
   compose = compose
6. extra- = outside,
   cellular = cell
7. herbi- = herb, vorous = eat
8. inter- = between,
   phase = phase
9. photo = light, syn = with,
   thesis = setting in order
10. spermato- = seed,
    genesis = production
11. taxo- = arrangement,
    nomy = law
12. zoo = animal, logy = study of

Study Skill 6
Graphing Data

Men

Body weight	Brain weight/ body weight
57650	.023
66500	.020
78158	.019
67350	.020
74316	.019
73211	.019
60381	.021
63560	.023
72944	.018
74910	.015
68100	.018
55083	.024
58182	.022
81720	.015
72353	.017
52591	.022
65830	.019
69875	.016

Men, continued

Body weight	Brain weight/ body weight
51522	.023
65500	.020
61200	.025
59020	.018
63579	.019
88530	.016
120310	.011
106690	.012
66045	.022

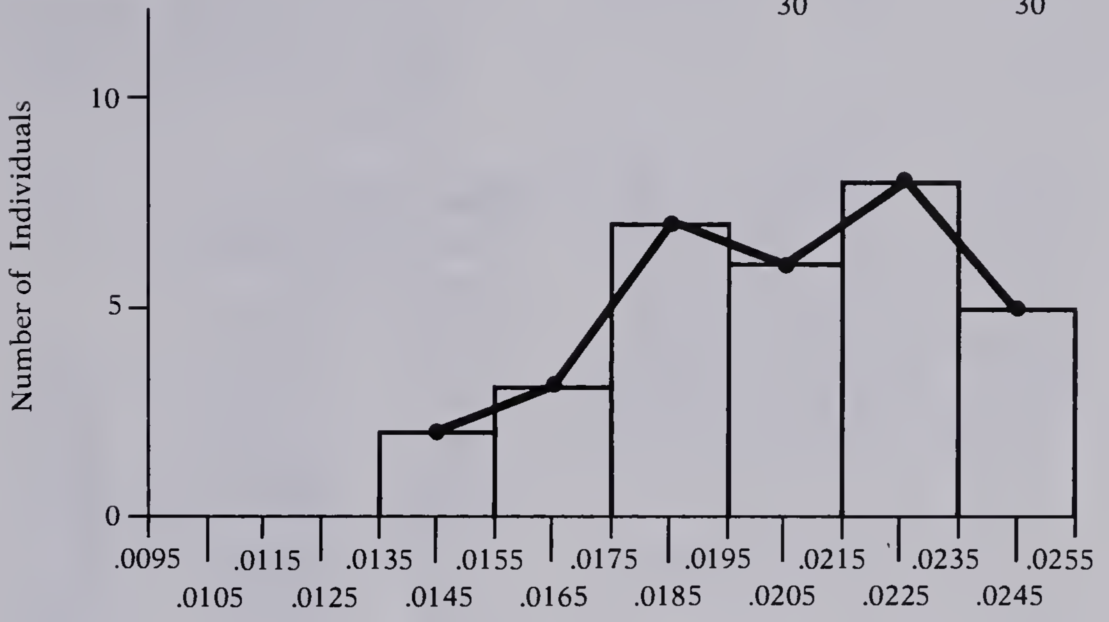
Women

Body weight	Brain weight/ body weight
66284	.018
63560	.015
65376	.020
69008	.020
49032	.022
70824	.017
62652	.018
67204	.018
53572	.023
61744	.016
71732	.019
46308	.023
52664	.021
49940	.023
55388	.024
59928	.020
72640	.018
67192	.020
54480	.022
58112	.024
51756	.022
50848	.025
45400	.026
64468	.019
68100	.016
56296	.023
48124	.023

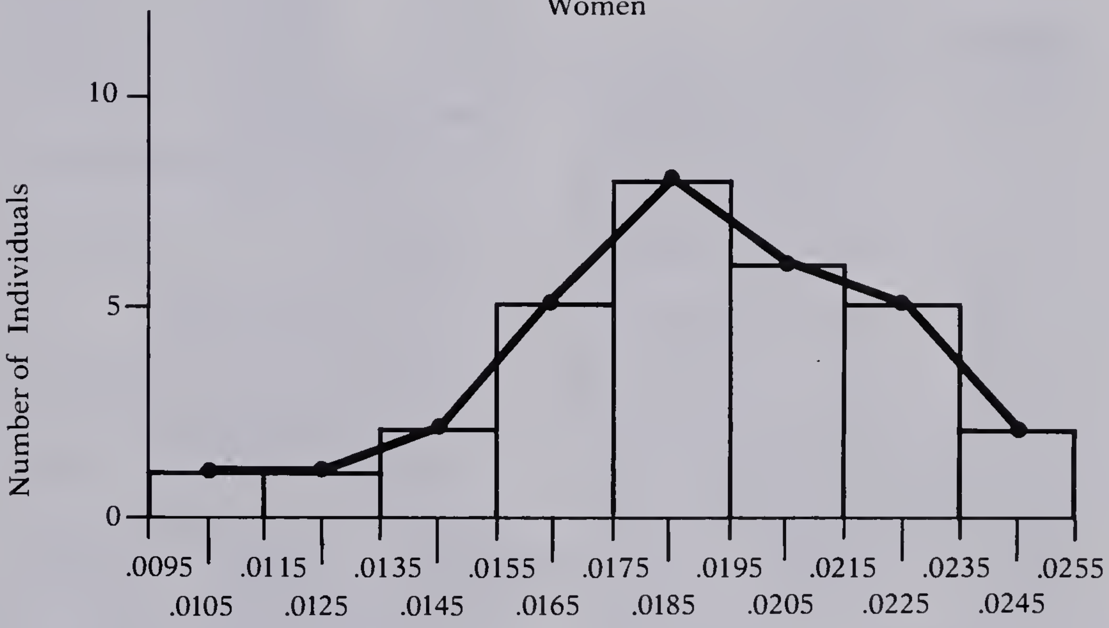
Conclusions:

The graphs should illustrate that there is not a significant difference in brain weight/body weight ratios in the two sexes. The two graphs have some similarities; at the mid-range the curve is about the same for both, with a slightly higher proportion of men to women in this range. At the lower and higher ranges there is more variance between men and women. For men the range begins at a lower brain weight/body weight ratio (.011 vs. .015). The highest point of range is the same for both, with a higher percentage of men to women at that point. The largest number of men were recorded at about .0185; the largest number of women were at about .0225.

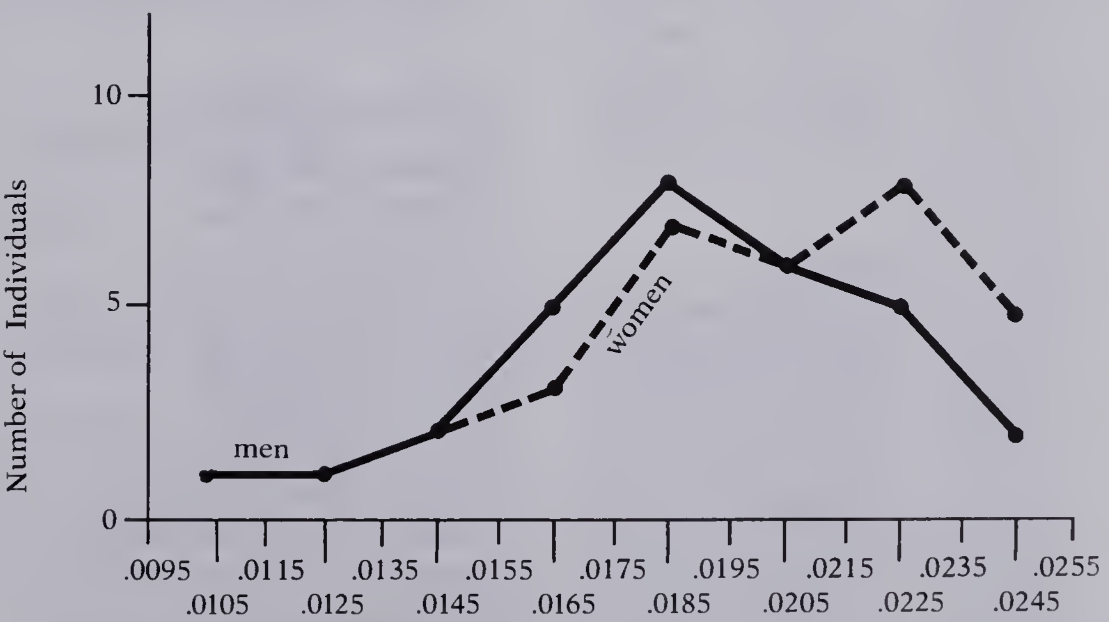
Range of brain weight/ body weight ratios	Midpoint	Number of men	Number of women
		8	7
.0195–.0215	.0205	6	6
.0215–.0235	.0225	5	8
.0235–.0255	.0245	2	4
		30	30



Ratios of Brain Weight to Body Weight
Women



Ratios of Brain Weight to Body Weight
Men



Ratios of Brain Weight to Body Weight
Graphs combined

Study Skill 7

Using Models in Biology

RR 25% RW 50% WW 25%

Tally Sheet 1

Generation	Number of "Offspring"		
	RR	RW	WW
1	0	1.0	0
2	.25	.5	.25
3	.25	.5	.25
4	.25	.5	.25

(Ratios are approximate)

1. The ratios of genotypes tend to follow Mendel's laws for a homozygous cross between dominant and recessive, and results in a genotype ratio of ½ to ¼ to ¼.
2. The R allele will increase in frequency relative to the W allele.

Tally Sheet 2

Generation	Number of "Offspring"		
	RR	RW	WW
1	.275	.45	.225
2	.327	.49	.183
3	.36	.48	.16
4	.385	.47	.144

(Ratios are approximate. They were figured according to the Hardy-Weinberg formula, reducing WW by 10 percent at each step.)

3. That there is a slight shift in frequencies in favor of genotype RR, with a decrease in WW; the frequency of RW fluctuates at about a constant percentage of .45.
4. No, the proportions will fluctuate as each generation reproduces.

Tally Sheet 3
Answers will vary.

5. The model shows that in a small population sample there can be a wide variation in proportions of genotypes from one generation to the next.
6. Yes, the Hardy-Weinberg law seems to apply to the first mating model, where the equilibrium of genotypic ratios is maintained in successive generations.

Study Skill 8

Testing a Statistical Hypothesis

1. –2.53
2. –2.53
3. 0.006, 0.001
4. That there is better than a 99 percent chance that the drug is effective in speeding recovery. This result is considered very significant.

Study Skill 9

Using Calculations to Interpret Data

Year	K_x	M_x
1965		.002298
1966	1,076,204	.002775
1967	1,073,218	.002651
1968	1,070,373	.001817
1969	1,068,428	.001735
1970	1,066,574	.001407
1971	1,065,073	.001407
1972	1,063,574	.001224
1973	1,062,272	.001210
1974	1,061,039	.001162

Study Skill 10

Seeing in Three Dimensions

1. ventral
2. dorsal
3. anterior or frontal
4. posterior or caudal
5. lateral
6. anterior or frontal
7. dorsal
8. posterior or caudal
9. mid or medial
10. ventral
11. transverse section, cross section
12. longitudinal section, sagittal section

Problem Solving

Problem Solving 1

Murder at the Zoo

Miss LaRue, Area B

Lady Randall, Area H

Mr. Moriarity, Area F

Dr. Stone, Area A

Mr. Cratchit, Area H

Lord R's chauffeur, Area A

Lord R's parlor maid, Area A

"Crazy Mary," Area C or L

Professor Moon, Area E, G, or J

The Duke of Newton, Area K

Lord R's older son, Area G

Lord R's older daughter, Area K

Lord R's younger son, Area F or I

Lord R's younger daughter, Area A

Mr. Noroian, Area D

Miss Adams, Area C

Mr. Addison, Area C, E, or L

Mrs. Windsor, Not in areas D, F, G, or I

Lord Randall was murdered in Area F. The murderer was Mr. Moriarity, the zoo director.

Problem Solving 2

The Case of the Hooded Murderer

The murderer of Lord Robert had red hair (aa) and had free ear lobes (EE or Ee). Virginia was the murderer because she had red hair (aa) and was the only living member having red hair who could have inherited the E gene.

Problem Solving 3

In the Teeth of the Evidence

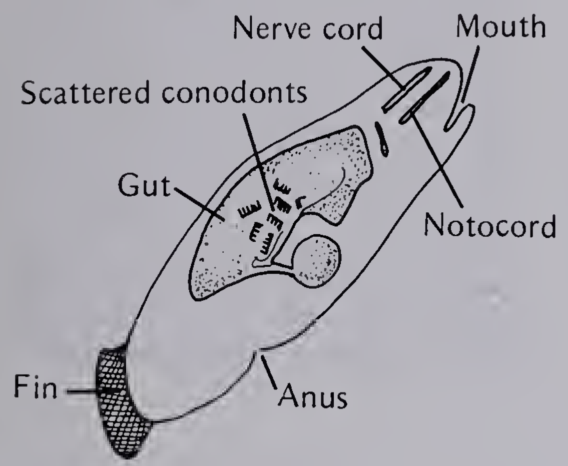
In the Teeth of the Evidence encourages students to speculate and argue about the conodont animal—as biologists have. When students have stated their hypotheses in falsifiable form and drawn the sketches, give them the following additional information.

In the late 1960s paleontologists Harold Scott and William Melton found some fossilized animals that contained conodonts in their guts. The animals were about 70 mm long and looked something like the modern *Amphioxus*, having notochords, complete digestive tracts, and rudderlike fins. Scott and Melton have hypothesized that the conodont animal was a protochordate, which could account for the many invertebrate characteristics of conodonts. They picture the conodonts as being assembled into a basketlike filtering structure in the gut, though the conodonts in their fossils were scattered. (That could have resulted from pressure.) Secretory tissue in the gut could have formed apatite.

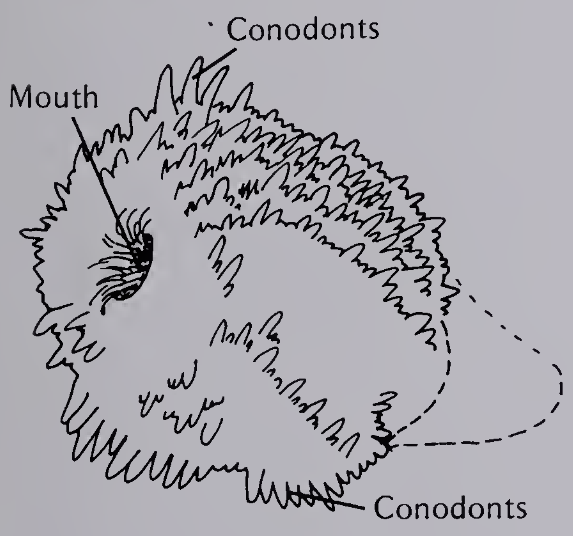
Others, however, think Scott's and Melton's animal was a predator that fed on smaller, nonchordate conodont animals. If so, that would account for the presence of the scattered conodonts in the gut region. According to M. Lindstrom, the real conodont

animal was probably a small marine worm having conodonts arranged around its mouth. A similar interpretation is that conodonts come from *Odontogriphus*, the flattened wormlike fossil animal shown. However, neither of these nonchordate interpretations explains the growth of conodonts by accretion, as does Melton's model. A completely satisfactory explanation is yet to come.

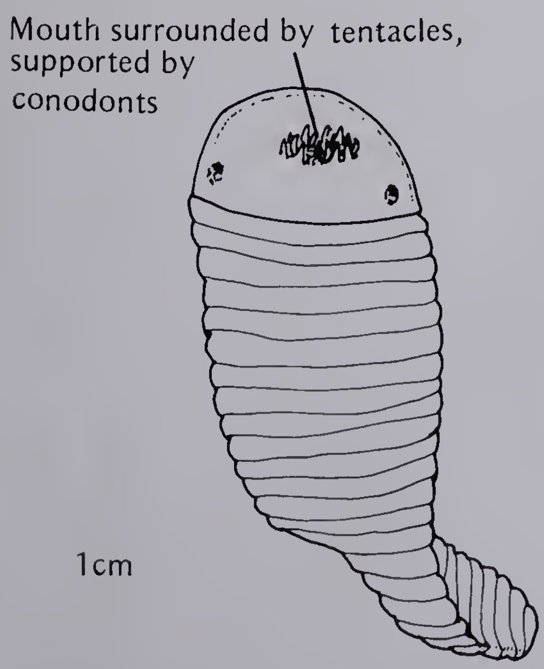
Scott's and Melton's animal:



Lindstrom's animal:



Odontogriphus:



Problem Solving 4
The Islands Utopia

Chart 1

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
U. Major	*I. alboptica* (species 1)	A-L	75% red 25% white	15–30°C	100% wild-type
U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% wild-type

Chart 2

Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
U. Major	*I. alboptica* normal variety	A-K	75% red 25% white	15–30°C	100% wild-type
	I. alboptica mutant variety	A-L	75% red 25% white	15–38°C	100% wild-type
U. Minor	*I. alboptica* normal variety	M	100% red	15–30°C	100% wild-type

a. mate and produce a hybrid species

b. remain separate species

Chart 3

	Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
a.	U. Major	*I. hybrid* (species 2)	A-L	100% red	15–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% wild-type
b.	U. Major	*I. species 2*	A-K	100% red	15–30°C	100% wild-type
		I. species 3	A-L	100% red	15–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% wild-type

Chart 4

	Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
a.	U. Major	*I. hybrid* (species 2)	A-L	100% red	10–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% striped
b.	U. Major	*I. species 2*	A-K	100% red	10–30°C	100% wild-type
		I. species 3	A-L	100% red	10–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% striped

Chart 5

	Island	Species	Distribution	Eye color	Range(s) of temperature tolerance	Wing pattern of males
a.	U. Major	*I. hybrid* (species 1)	A, B, E, F, G, H, K, L	100% red	10–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% striped
b.	U. Major	*I. species 2*	A, B, E, F, G, H, K, L	100% red	10–38°C	100% wild-type
		I. species 3	A, B, E, F, G, H, K, L	100% red	10–38°C	100% wild-type
	U. Minor	*I. alboptica* (species 1)	M	100% red	15–30°C	100% striped

1. a. The original species diverged into two species, *I. hybrid*, or species 2, on Utopia Major and *I. alboptica*, or species 1, on Utopia Minor. The distribution of the hybrid species is restricted to all but areas C, D, I, and J. Instead of a 75 percent to 25 percent ratio of red to white eyes they are all red-eyed. Their range of temperature tolerance is now 10°–38°C as opposed to an initial range of 15°–30°C. *I. alboptica* on Utopia Minor has kept the original tolerance range of temperatures; the differences are that the species is 100 percent red-eyed and 100 percent of the males have striped wing pattern.

   b. The original species diverged into three species: species 2 and species 3 are on Utopia Major; species 1 is on Utopia Minor. Species 2 and 3 differ from the original species in having a wider range of temperature tolerance (10°–38°C as opposed to 15°–30°C); they are both 100 percent red-eyed as compared to the original ratio of 75 percent red-eyed and 25 percent white-eyed. The distribution of species 2 and 3 is restricted to all but regions C, D, I, and J on Utopia Major. The species on Utopia Minor differs from the original species only in having 100 percent striped wing pattern in the males and in being 100 percent red-eyed.

2. (Answers will vary.)
Wing pattern change: A selective advantage in mating caused one variety to succeed and the other to die out.
Temperature tolerance change: Being able to tolerate higher or lower temperatures as the climate changed gave a selective, reproductive advantage.
Eye color: The predatory birds preyed on white-eyed individuals, causing the red-eyed variety to prevail, a matter of survival of the variety most adapted to the changed circumstances in the environment. Red-eyed flies had better vision, a factor that did not have a significant effect on survival until after the volcano erupted. In this brief period of darkened skies some red-eyed flies colonized Utopia Minor and the allele accounted for 100 percent red-eyed flies in this population.